S&T in the Asia-Pacific Region

S&T Investment Strategies and Policies viewed from short visits to 11 countries plus Hawaii

Japan
Korea
Philippines
Hong Kong SAR
Vietnam
Thailand
Malaysia
Singapore
India
Australia
New Zealand

7 July - 4 November, 2001

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Foreword

The US Navy's Office of Naval Research (ONR) has maintained an International Field Office (IFO) from its very inception in 1946. While the IFO's staffing, mission, and operational approach have all evolved with changes in national need and technological capability, the basic objective remains the same: to help the US ensure that it has access to the best minds in the world, and simultaneously promote the US's open approach to research and data management. While the ONR IFO is just one of the many mechanisms this country uses to enhance international S&T connectivity, it is unique in its longevity, the accessibility of ONR research programs to international participation, and the quality and size of its overseas scientific and engineering staff.

I had the privilege of serving as Technical Director of the IFO during 1995 and 1996. Following that tour I returned to ONR Headquarters, first as Special Advisor to the Chief of Naval Research, then as ONR Chief Scientist. In late 2000, following discussions about possible expansions of the office (see text) and a zero-based review of ONR's international activities, I was asked -- because of this background -- to assess our posture throughout the Asia-Pacific region. For a number of reasons, including the international situation at the time and the schedules of the US Country Team staffs who were expected to help host my visits, my assessment addressed only the 11 countries shown on the title page, and focused particularly heavily on Australia, where we had hoped to open a new Branch Office. My program was closely coordinated with the new Office of the S&T Advisor to the Secretary of State (STAS), which at the time was developing its own strategy and methodology.

My visits were arranged and supported by the IFO, in particular the Tokyo office under the able leadership of CDR Frank Pennypacker, and the Singapore Office, where Mr Darren Bergan has set new high expectations for US DCA activities; by the US Security Assistance and Environment, Science and Technology staffs of the US Teams of the countries I visited; and, especially in Australia, by my able Exec, Ms Tania Roman.

The trip required four months on the road, living out of a suitcase; hardly fun, and not in the most peaceful of times. This document comprises the reports I wrote and sent as I went, starting with my initial planning; thus the style is a bit uneven, particularly since I was often accompanied by others who can and should help with reporting. Only the last two reports -- an overall appraisal of Australia's innovation system, and my summary and major recommendations -- were composed in retrospect. But on rereading what I wrote, I would not at this point change anything beyond some clumsy syntax.

Two people deserve my everlasting thanks for making this trip tolerable, even sometimes pleasurable: my wife Cynthia who as always traveled with me; without her, I would have been an intolerable rag bag by week two; and my Exec Tania, who kept the home front held together for us. Super ladies both.

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Report 1: ONR's International Posture: Background and Preparations for the Asia trip
6 July 2001

In late 2000, ONR submitted to the State Department a request to open a two-person branch of the International Field Office (IFO) in Australia. ONR proposed to station Dr Peter Majumdar, a ships technology expert, at the Australian Maritime Research Laboratory in Melbourne, and base myself in Canberra. We expected that there would be adequate ship and vehicle S&T cooperation between the two countries, and adequate innovative ship related developments by Australia and other countries in the region, to justify a long term commitment to the Melbourne position. My task was to assess whether there was enough other academic, industrial, and government lab S&T in Australia to justify a second person.

ONR's request ultimately was turned down by the US Ambassador, for reasons that remain unclear but appear to be a combination of Embassy administrative burden, an already large US military presence, a belief that there was not enough S&T in Australia to justify two positions, and a suggestion that we could accomplish our objectives TDY. In addition, at the time of our request, State Department was negotiating with NASA for assignment of one of their scientists to the position of Science Advisor to the Ambassador, which would increase the Embassy's ability to support our need for information on S&T developments in the area.

Rather than immediately reclama the Ambassador's decision, ONR decided to reassess its overall posture in the Asia-Pacific region, as part of its Zero Based Review of the relationship between the NFFTI S&T Advisors to US Military Commands, and the IFO. An initial conclusion of the ZBR was that the two organizations have orthogonal functions and quite different staffing requirements, but that both should contribute to the CINCs' responsibility to shape the environment in their AORs, and in particular should support their regional and country engagement plans. S&T can be a powerful tool for international engagement and cooperation, and underpins the more formal DOD and Service agreements associated with cooperation in defense systems and interoperability. ONR IFO can thus contribute to advancing the national agenda both through support of the CINC, and through closer interface with other US international S&T programs and offices. ONR can play a particularly strong role in such activities because of its global reputation for excellence in research sponsorship, and its long history -- since 1946 -- of international presence and outreach.

Commensurate these decisions, Dr. Majumdar was asked to remain at the IFO London office with part of his assignment being to enhance ship technology interactions in Australia through TDY visits. I was tasked to visit a number of countries in the Asia-Pacific region, but with an emphasis on Australia, to evaluate our overall posture in the region and suggest possible improvements. I have attached my proposed itinerary and a copy of the background memorandum I prepared for US Embassy staff; these outline my intended approach to my task.

In addition to the logistics associated with a 4 month TDY to 10 or 11 countries plus Hawaii (which have been nothing short of an extended nightmare), my preparations have consisted of participation in the ZBR in London; an in-depth analysis of CINCPAC plans (to be reviewed with J45 staff in Hawaii); discussions with the international offices of DOD (AT&L, USD[S&T]), the other Military Services, NSF, NAS/NAE, NOAA, and several other agencies; and extensive consultations with the Office of the Science and Technology Advisor to the Secretary of State (STAS) and various other DOS desks and bureaus with EST (Environment, Science and Technology) interests. I have received exceptional support throughout my preparations from STAS, from ONR's Tokyo and Singapore offices (CDR Pennypacker, Dr. Narita, Mr. Bergan),

and from my assistant Ms Tania Roman of Noesis. With the assistance of CDR Pennypacker and Mr Andy Reynolds of STAS, I have also received excellent support from SAO and EST officers in most of the countries I plan to visit.

During my preparations I have developed a number of impressions that will shade my investigations and ultimate recommendations. These include:

- Arranging a trip of this magnitude and duration from ONR Headquarters is exceedingly difficult, and in general should not be attempted. On the other hand, there is a very large amount of international travel performed by ONR POs that is not well integrated with the IFO or ONR's overall international strategy (which itself is not well developed).
- ONR's international efforts have historically focused on identifying and exploiting S&T opportunities. Between special programs managed by the IFO (visits, 'knowledge mining', VSP, CSP, NICOP) and the international contacts developed in the normal course of S&T by ONR POs, their PIs, and NRL and Navy Lab researchers, complemented by interactions with other Service and DOD colleagues, ONR has managed to stay abreast of developments in many areas of importance to DON. Other effective techniques have included long term support of symposia series, e.g. in Military Psychology and Naval Hydrodynamics, and participation in or lead sponsorship of major international oceanographic programs, from WOCE to ASIAEX.

Successes however have been spotty, and there is a wide range of opinion on the part of ONR Departments and POs regarding when, where, and how they should support international researchers and programs. Similarly, there are various opinions regarding IFO initiatives such as NICOP; for many, it is just one more example of a program with such small funds that isn't worth the effort.

Almost all ONR solicitations, particularly those supported by 6.1 and 6.2 funds, are open to proposals from all nations, and ONR's grant mechanisms enable relatively easy transmission of funds. Barriers to wider international participation in the core research programs include individual perceptions and interests by the POs (not surprisingly, international scientists at NRL and ONR appear more likely to collaborate with and support other international scientists), logistic and administrative difficulties in identifying key investigators and incorporating them into research strategies, and the belief by many -- including much of the US scientific community -- that US funds should support US scientists except for very special expertise, or resources such as access and logistics that are not available in the US. There are also many disincentives for scientists from some nations to participate in US Defense sponsored programs.

While my proposed visits should yield suggestions for improving ONR's international program as currently practiced (e.g., a consistently applied ONR policy on what to support and why; better exploitation of PO international travel; changes to staffing policies), my preparations have identified some questions of strategy that are perhaps more important. The first is whether ONR should try to do more than simply identify and exploit S&T opportunities for their own sake. This question is raised by the ZBR decision to better support the CINCs engagement efforts, and by the commitment to closer interaction with other agencies and the Department of State, to advance the overall national EST agenda. ONR has programs and people that can contribute strongly to such strategic objectives, much in the same way that ONR can support Congressional interest items, even when they may not -- in the minds of the POs -- represent the very best S&T in areas that the POs consider most important.

As one example, CINCPAC strongly promotes enhanced regional cooperation, and multilateral collaboration, training, and exercises in military skills like humanitarian assistance, disaster

reduction, SAR, environmental security, and peace operations, as well as CT, CD,and anti-piracy, both for their own sake and to enhance interoperability and regional stability. It is however difficult to identify much ONR activity that would contribute to these areas. If they are central to engagement and we are to support the CINC, then perhaps we should consider modifying our investment strategy appropriately. As another example, US recently signed an S&T agreement with Vietnam; the first meeting of the associated joint committee will be held this November. IFO Tokyo has just made its first visit to VN, and at issue is how much effort should be dedicated to playing a strong role in this developing cooperation. ONR's own proposal to open a branch in Australia, and to station a representative in South America, are other examples of initiatives that may be viewed as strategic rather than tactical, albeit not connected to broader US initiatives; indeed, it may be better to devote such resources to VN.

If ONR does adopt a policy of playing a more strategic role in international EST activities, then its plans and programs will need to be coordinated more closely with other elements of DON and OSD (e.g. ISA) as well as other agencies, and its approach to overseas staffing and sponsorship will need to be adjusted.

A second strategic question addresses the balance of IFO efforts between identifying specific promising technologies and investigators, and attempting to discern the investment strategies and policies of international partners, both individual states and and supranational organizations such as the EU and industry. The IFO is now heavily biased toward the former, although there is reason to believe that more IFO time dedicated to understanding strategies and patterns, with detailed follow-up left to POs and PIs, may have better long term payoff. In such a mode the IFO would guide, support and coordinate ONR's international activities much more than now.

A third question of significant national as well as naval concern is the degree to which the US may miss critical or disruptive technologies, and therefore develop undesirable dependencies, because of changing demographics, globalization, and policy decisions. As with investment strategies, ONR IFO could help with such assessments, but would need a different mix of talent, and different levels of support from Headquarters, than at present. E.g.,

- I am deliberately visiting a number of places that have not been frequented by ONR. Although Embassy staff have in general been very supportive in arranging my visits, it is clear that most of my interests lie outside the purview of the SAO (ODC, USDAO, JUSMAG, etc) and are more aligned with the EST or Economic section. Assuming that the same will hold for many IFO visits (it was true for me also in Europe), close coordination with and support by STAS at DOS will prove very important, if ONR is to take full advantage of country team support. It may even be reasonable to consider assigning ONR scientists to country teams to provide such support as well as enhance the teams' scientific expertise, as NASA has done in Australia.
- I was impressed by Hugh Casey's use of a consortium to develop advanced knowledge management tools. Peter Majumdar, during my tenure in London, likewise demonstrated the value of the consortium approach for research with European marine industries. And, ONR's sponsorship along with DARPA and others of ATIP, has provided us much information about MEMS, HPCs, and nanoscience in Asia at very low cost. In general, I believe that joint sponsorship, participation in supranational or other collaborative programs (e.g., EU, IOC, industrial or academic consortia), and similar activities can significantly improve information exchange, and reduce redundant initiatives. I will be looking for such opportunities in Asia during this trip.

DR CRAIG DORMAN
ASIA-PACIFIC VISIT
JULY-NOV 2001

BACKGROUND INFORMATION FOR US PERSONNEL

Itinerary:
7-10 Jul: SFO: PACON 2001 (Keynote Speaker)
10-13 Jul: Honolulu: CINC, NFFTI, ONR, Oahu meetings
13-16 Jul: Maui: MHPCC, PDC (16th)
18 Jul-4 Aug: Japan (Tokyo, Yokosuka, Yokohama, Sapporo)
4-11 Aug: Korea
11-15 Aug: Manila, Philippines
15-19 Aug: Hong Kong
19-23 Aug: Hanoi/VN
23-29 Aug: Bangkok, Thailand
29 Aug - 1 Sep: Kuala Lumpur, Malaysia
1-12 Sep: Singapore (Possibly India 8-12 Sep)
12-17 Sep: Perth & WA
19 Sep - 29 Sep: Sydney, Canberra
30 Sep-20 Oct: Adelaide, Melbourne, Tasmania
21-28 Oct: Brisbane, Townsville
28 Oct - 4 Nov: NZ North Island

My specific task is to help ONR assess, then improve its S&T posture in the Asia-Pacific region. My visits will therefore focus on larger, strategic issues of S&T strategy and strength, rather than specific projects on which we can collaborate; recommendations regarding detailed visits for such purposes, and for possible changes to staffing and location of our branch offices (currently Tokyo and Singapore), will be an output of my trip. I will want to try to gain an appreciation of each nation's priorities with regard to S&T - both for defense, and for commercial development. I will want to understand their investment and development strategies, and their organization for education (especially graduate education), research, and development - in federal labs, academia, and in industry. I will want to learn what they believe to be their specific strengths, whether they are pursuing independent or novel technological paths, and to what degree they're involved in regional or global development and commercial activities. Also who their major partners are in each area of desired national strength.

I have developed my agenda in close coordination with the Office of the S&T Advisor to the Secretary of State, and have discussed my plans with appropriate State Department Desk and Bureau personnel, and with CINCPAC planning and Security Assistance Staff. ONR desires to improve the degree to which it supports both the CINC and the national EST agenda, and my visits will help me advise ONR, State, and CINC staff on how we can better cooperate.

My priorities for contacts in each country are:

1. US Country Team. My primary POCs will be the EST Counselor (if any - otherwise the individual with local S&T responsibilities), and the ODC/SAO (alternatively, Defense or Navy Attaché). I will communicate with them by email before visiting, then make a country team visit my first stop. I also will be requesting assistance in arranging calls on host nation representatives,

or at least suggesting whom I should see. Optimally, Embassy personnel will accompany me on key visits.

2. Host Country S&T Personnel: I should call upon someone from the R&D side of the Defense sector - acquisition/equipage, or S&T if they have anyone so designated. I am interested in what types of technologically advanced capabilities they are pursuing, where they go for technology, what they see as their indigenous strength, and who they view as priority partners. It is however equally important for me to visit host civil sector agencies - e.g., Ministries of Science, Environment, Industry; their Academies; and their versions of S&T sponsors and managers like NSF/NIH/NASA. I will want to understand how they're organized, as well as their unofficial, or influence, alignments. I will want to know about their views of indigenous strengths, their investment strategies, funding processes (e.g., peer review or old boy?), concerns, priorities (e.g., development vs environment, to be overly simplistic), assessment of various aspects of national infrastructure that influence technological opportunities and research, sensitive areas and topics (e.g., can we use overhead info like LANDSAT without offending them? Can we use GPS on field work? Is there close interface between military and civil developments and technology?), alignments of industry/universities with government labs/agencies, and with international people and places.

3. Industry, Universities, Government Labs, T&E sites, NGO’s, etc: ONR Program Officers have suggested some specific places they believe important, but I prefer to take the hosts' and Country Team's lead whenever possible on what they think I should see. I want not to retread old ground, albeit calls on PIs who are important in ongoing collaborations are important. ONR's S&T scope covers about everything but agriculture - and my other customers care even about that. Essentially I'm omnivorous with regard to scientific discipline, albeit I can and will explain ONR's priorities to my hosts.

Report 2: 7-17 July 2001: Hawaii Observations
A: CINCPAC Engagement Strategy
B: Supporting Mechanisms and ONR Opportunities
Itinerary

A: CINCPAC Engagement Strategy

CINCPAC's principal engagement theme for the AOR is to promote multilateral interactions to improve trust and transparency among the nations in order to enhance the regional security environment, while simultaneously improving their capabilities to support shared responsibilities in support of real needs. Major cooperative development programs involve Japan, Korea, Singapore and Australia; the latter is of particular interest to naval components. Four 'shared interests' of all the AOR nations, discussed at the last CHOD meeting, are counter -terrorism, -drugs, -piracy and -WMD. HA/DM, SAR, and Peace operations are also common themes that transcend purely military-military interactions and provide additional opportunities for multilateral collaboration . ADM Blair has energized both his own headquarters and component commands in support of this strategy.

Although the focus is clearly upon multilateral exercises, planning, and operations, the capabilities and interests of the individual nations of course differ, as do ONR's opportunities for S&T engagement. Some points raised during conversations with CINCPAC, CINCPACFLT and SUBPAC staff follow (in the order in which I will visit).

Japan, like the US, faces a changing military mission and the associated challenges. Despite a fairly large number of DEAs and cooperative R&D programs, and the importance of US-Japan relations, there is less defense S&T interaction than might be expected, perhaps because of the dominance of commercial over defense interests in Japanese technological strategy. Two impediments for the near future are the economic recession and its impacts on S&T investment, and differences with Korea on historical perceptions, which have resulted in cessation of mil-mil relations between these two US allies.

Korea is maturing as a nation and in its national security concerns, and is no longer focused solely on the north. At issue is how far into its S&T strategy, both for defense and for industry, this expanded focus has penetrated (Korea has been unwilling to share its classified defence S&T plan). There are many DEAs but only few cooperative R&D agreements; an experienced DCA officer noted that the easiest way to collaborate with Korean companies is to partner, ie acquire partial interest in or establish joint programs with them. Perhaps as a result, much of the military R&D interaction has become predominantly one way and US labs are losing interest. There are however many opportunities and good justification for collaboration; Samsung flat panel displays are an example of capabilities we need. The differences with Japan will impact plans for multilateral programs.

The **Philippine** military is badly underfunded. The US has provided much equipment and training, but with little apparent long term effect. At issue are unit integrity, command and control, management, maintenance, and corruption.

Hong Kong was not discussed.

Vietnam shows promise of being the next Asian country of rapid entrepreneurial growth. They are still hesitant regarding mil-mil activities with the US, but understand the local and regional

importance of multilateral cooperation in HA/DM, SAR, etc., and are very interested in business education and other interactions. The recent US-VN S&T agreement, to be followed by the first meeting of the Joint Committee in November, has spurred considerable interchange.

Thailand has a very professional military, and participates broadly in bi- and multilateral exercises and training. More than any of the others they are interested in becoming 'joint' in operational capabilities. The Army Medical Research Institute plays an important role both in the country and throughout the region, as does the Asia Disaster Preparedness Center. There is considerable interest in high tech based industry, although no one mentioned any military S&T engagement.

Malaysia has demonstrated a considerable interest in and ability at reverse engineering. There is no strong mutual defense S&T interest, although the Malaysians suggested four topics, associated with human factors and equipment performance in humid tropical areas, during an OSD visit a few years ago. Malaysia has established a national anti-piracy C&C center on the coast that could be a potential C4I 'gold mine' for the region. They have also constructed a "multimedia super corridor" that extends from Kuala Lumpur to the airport, that is the national centerpiece for commercial development. They provide unimpeded net access and a furnished office to entrepreneurs, and would like this area to become a 'silicon valley' and entertainment leader. This represents a major national investment, with as yet no clearly defined niche; and the investment appears to be confined to this one locale, with little offered to the rest of the country.

Singapore is "pushing harder than we're pulling". Of interest to the CINC is why they want, what they want. They have expressed interest in participation in several ACTDs, but largely as observers. CINCPAC staff is suggesting that they bring their shallow water MCM capabilities to the table. RADM Lim is a key figure in their international outreach. In addition to their collaborations with the US, they have partnerships with many other technologically advanced countries, and have proved adept at integrating the best from a variety of disparate sources. Although small in size and population they are one of our most serious partners, at least bilaterally. There do remain some issues with their neighbors. Commercially, they are a major 'middleman' in shipping and trade, as well as a financial and high tech center.

CINCPAC would very much like to increase interaction with **India**, as soon as the diplomatic situation permits. At present, mil-mil contacts are impeded both by the sanctions, and by the tight control by the Ministry. They are aware that ONR has been communicating with the EST Counselor, Marco DiCapua, and that I may visit.

Australia is a major partner with quite similar perceptions to ours on many issues. Recent decisions regarding strategic alliance with the US on naval, especially submarine, matters are a focal area for CPF and SUBPAC activities. There is an Australian exchange officer at COMSUBPAC, and CPF is working to arrange one for their staff. The upcoming joint PCO/PXO training in Perth is a centerpiece of collaborative operations. Australia is also a welcome participant in several ACTDs. CPF expressed strong support for ONR's efforts to establish a branch of the IFO in Australia. Staff noted, however, that there are some differences of opinion regarding directions and pace of development between RAN and DSTO. While CINCPAC is also supportive of the increase in Australian connections, he believes they should not overshadow attention to enhanced regional engagement and multilateralism. On this note, senior staff members were extremely interested in the opportunities throughout the AOR which might be offered by agency (including OSD/service) augmentation of Embassy EST staff, as NASA has provided in Australia.

New Zealand has not been active in the engagement process and was not discussed except to note the lack of interaction.

Although I am not visiting Taiwan or Indonesia, the following comments may be pertinent. First, staff was disappointed that they (and mainland China) were not on my itinerary. Both remain important, particularly in the multilateral context. ONR of course has extensive S&T projects with Taiwan. However Taiwan is pessimistic about further economic and technological growth as opportunities open in mainland China, Vietnam, Malaysia and elsewhere. One apparent deficiency is that, as opposed to Singapore, they lack expertise in integrating ideas and technologies from diverse sources.

At issue for Navy in Indonesia is status of NMRU-2. CDC, CINCPAC and international organizations view the NMRU as an extremely valuable asset. The importance of its role can be expected to increase as the EID threat becomes clearer. If is turns out that the unit must leave Indonesia, it will be extremely important to identify an alternate location in the region. Indonesia is obviously a key player in anti-piracy, and there appears to be progress on this topic with the current administration. The same applies to navigation through the straits, and international cooperation and support under UNCLOS may offer opportunities for multilateral engagement.

Comment: CINCPAC is clearly driving hard for enhanced regional collaboration. He has developed or coopted many mechanisms to pursue this strategy, some of which are discussed below. Although naval components appear at the moment to be more narrowly focused on the opportunities arising from the enhanced strategic alliance with Australia (and bilateral aspects of other naval incidents), they are willing followers of, and active participants in, CINC's strategy. For example, SUBPAC is engaged in planning multilateral discussions, via a Pacific-wide submarine conference now scheduled for August (delayed because of the Greenville incident). At issue for ONR, if indeed we seriously wish to support the CINC, is how S&T can play a more significant role. One suggestion raised several times during discussions is to provide technological assistance to PACOM nations to help them improve their ability to participate in multinational exercises and operations in tasks of common interest. Perhaps the most salient examples were raised at SUBPAC: most countries' subs still communicate with HF; a simple SATCOM antenna would enhance their ability to interact with US forces, even if they had to then use commercial SATCOM connections. Similarly, they lack precise navigation capability while submerged, and in areas of strong current quickly get 'out of the box' and thus endangered. A relatively cheap INS, or XBT-like buoys with GPS, could help solve this interoperability problem. Similar examples abound; the challenge is not to try to bring other nations up to a par with US technology, but simply to provide capabilities that enable them to employ their extant forces in appropriate roles with our own and other nations, without unduly endangering themselves or others, and within a common, combined if low bandwidth C&C structure.

B: Supporting Mechanisms and ONR opportunities.

I want to start this section by commending the level of coordination among the NFFTI science advisors and the new ONR MidPac Office. In addition to the spirit of cooperation there is a nice blend of talent and longevity in position, which it will be important to maintain. The various staffs all seemed to appreciate their advisors, and the lack of comparable presence by the other services was notable. Further, I believe the new ONR Mid-Pacific Branch can play a major role in further coordination among the advisors, and significantly augment their ability to bring S&T to bear upon the CINC engagement strategy, if that is how ONR chooses to use that office.

As noted above, ADM Blair has either developed or coopted a wide range of mechanisms to implement his strategy of enhanced regional cooperation. With the support of local ONR staff, I was able to visit several of these, as well as some that have not yet been incorporated into the 'net' of engagement mechanisms. One I did not visit but that figures prominently is the Asia Pacific Center for Security Studies. It offers multinational training and education, augmented by introduction to IT tools, to national security leaders throughout the region. More focused training is offered by the Asia Pacific Peace Operations Capacity Building Program, which employs games and seminars to supplement the several varieties of classroom education and exercises in HA/DM, SAR, and various aspects of PMO/PKO offered by the UN, NGOs, and other CINCPAC organizations. In a similar vein, the CINC uses his CHOD meetings, combined with DV and staff talks, to discuss and promote the strategy and its central elements and common interests. These interchanges are supplemented by reorientation of the entire exercise schedule toward a regional and multilateral focus, tailored to the geography and issues of the oparea. Nations are invited first as observers, with increased levels of participation as interest and ability grow. To help the nations prepare for these exercises, the CINC has formed a Multinational Planning Augmentation Team (MPAT) that deploys as needed to complement existing host and participating staffs.

These exercises and the associated planning help nations discover where their strengths can be most effectively combined with others toward the common good, particularly in areas of mutual interest such as HA/DM, SAR, CT/CD, etc., and not necessarily with US lead. While to date most of the US leadership for this approach has come from CINCPAC staff, responsibility is now being devolved to Joint Mission Force Commanders, whose day-to-day activities emphasize component capabilities, but who assume joint responsibilities as assigned. Another part of this strategy is to introduce new technology and capabilities into this exercise and operational mix through experimentation. The Marines' decision to employ an Australian fast ferry for normal troop movements in lieu of reliance upon TRANSCOM is an example of this approach. CINCPAC's use of ACTDs, particularly in C4I, as the principal mechanism for operationally-relevant and fleet/force driven technology advances, is another aspect of this strategy (CP has 13 ACTDs underway, and claims success in all its previous ACTD programs; ACTD development and execution are the principal focus of the CP science advisor, and are at the core of CP's transformation strategy).

CINCPAC has developed two web based information management programs to support both the staff and the collaborating nations throughout the AOR. The Virtual Information Center (VIC, www.vic-info.org) analyzes open source information to complement what the intelligence community provides. While principally designed to support staff, it is unclassified and accessible to anyone who registers. The Asia Pacific Area Network (APAN, www.apan-info.net), on the other hand, is deliberately designed to be a one-stop shop for AOR nations for national security related information and links. While it started as an information-push cite, it is expanding into distance training and education, support of the MPAT, client based support, and other outreach activities. APAN does not yet have an S&T section, but my briefers expressed great interest in such an addition. This is an opportunity where ONR could bring both its IT expertise and its S&T leadership immediately to bear to support a major CP engagement mechanism; I suggest that the MidPac Office could take the lead in supporting the CP advisor and APAN staff if ONR believes it worthwhile to use this mechanism to start to play a more active role in bringing S&T to bear on CINC strategy (incidentally, APAN is supported by CINC O&M funds, and needs S&T/R&D help to develop new capabilities)

Because of the emphasis upon Humanitarian Assistance/Disaster Management (HA/DM) as both a common interest topic and an area of true need for improved capability, I visited two organizations that are directly involved. The first, the COE for HA/DM, is located at Tripler Medical Center. It provides core courses, supports the International Red Cross in its Health Emergencies for Large Populations (HELP) courses, and in general functions as it name implies, as a center of excellence for promoting improved people/skill oriented capabilities throughout the AOR. COE-HA/DM works closely with the VIC and APAN, and provides resources to the MPATs as appropriate. The second is the Pacific Disaster Center, located on Maui. PDC provides GIS-based information and models about a wide range of environmental hazards, and complements the more skill-based, medical focus of COE. For a variety of reasons PDC has not been as supportive of CINC initiatives as either the CP staff or the Center itself would like, but the shift of its funding mechanism from an OSD/C3I contract to a cooperative agreement should help. A major concern is maintaining openness of all products while accessing and protecting a wide range of supporting information sources, some of which are proprietary or sensitive to the nations involved (e.g., detailed maps).

PDC is also well connected to other disaster preparedness and mitigation organizations throughout the region, and thus can both provide information support for comprehensive disaster management, and serve as a model and test bed for new capabilities. It would like to become a major player in developing a distributed hazard/disaster data architecture for the region. Together, the VIC, APAN, COE, and PDC can in my opinion become a very powerful and beneficial mechanism for engagement throughout the theater, as well as enhance our own nation's mid-pacific disaster preparedness; and ONR, again, has tools and the ability to help coordinate S&T input to these mechanisms, should it desire to support the CINC in this aspect of engagement. (A personal prejudice of mine is that CINC planning and intelligence staffs need to begin to employ modern sophisticated GIS tools, and PDC has expertise and data in this area. A geospatial approach to information management is a natural corollary to a multinational engagement strategy.)

I also visited four organizations that, while not directly involved with the CINC staffs, offer resources that could be of interest. The first is PACON, where I delivered the keynote address in San Francisco on 9 July. PACON is a non-profit NGO with both public and private members from many nations with Pacific region concerns. Its areas of interest are marine S&T, with most of the associated commercial and R&D activity focused on the littoral. The conference I attended was on marine technology for sustainable development, which relates closely to the Rio+10 UN Conference on Sustainable Development scheduled for Sept 02 in Johannesburg. NOAA (NOS) has been the primary US participant, but I heard many talks that I believe should be of interest to ONR PO's, if for no other reason than the littoral focus and the international complex of the group. PACON is headquartered on Oahu, and I have suggested to the Director of the ONR Mid-Pac branch that they would be a useful contact. As just one example, the first pacific area submarine conference will discuss submarine rescue; at issue is finding another topic that will both appeal to submariners and be openly accessible, for future conferences; it seems to me that some combination of ASIAEX and the PACOM-type topics discussed at this last conference (e.g., ship safety, waste prevention, coastal engineering, invasive species, contaminant detection, wave power) would be a very good fit and provide an improved understanding of the contributions of S&T to the operational forces.

The second organization is the International Pacific Research Center (IPRC), founded in 1977 at UH's SOEST under the US-Japan Common Agenda for Cooperation in Global Perspective. Support comes from the state/University, US science agencies, and Japan's Frontier Research

System for Global Change. The faculty and staff are international, and conduct research on three themes: Indo-Pacific ocean climate, regional ocean influences, and the Asian-Australian monsoon system, with plans for an Asian-Pacific Research Data Center. Given its focus on ocean issues and modeling, the impact of and international interest in climate, and the multinational nature of the IPRC staff, it would seem to again offer significant local potential to contribute to the CINCs engagement strategy.

The other two organizations are the Maui High Performance Computing Center and the Maui Space Surveillance System. MHPCC currently has three major parallel processing clusters, with a throughput of 2.3 teraflops; it supports several ONR/NRL and other service challenge programs. Its principal expertise is in signal and image processing, modeling and simulation, and training and engineering; it also desires to be a major data repository for BMDO in support of missile defense in the Pacific. It has a wide band link throughout the state (it provides internet connectivity to the schools), and to the MSSS on the top of Haleakala. MSSS's principal resources are its 1.2 and 1.6m telescopes, and the new 3.6 meter scope with adaptive optics. Both organizations are Air Force managed, MHPC through a new contract with the UH, and MSSS directly by AFRL. Combined, they are a potent resource for space science and operations as well as more traditional HPC 'shared system center' activities.

Comment: Many activities in Hawaii can play a significant role in the CINC's engagement strategy, and bring S&T into play as a much more significant player in the theater. As just one more example to complement those in the text, several organizations - e.g. PDC, MHPCC, IPRC - want to become major data centers, and if these efforts were coordinated and linked to CINCPAC's C4I architecture (e.g., COWAN), they could become powerful tools for enhanced regional cooperation. While ONR Hq has a tremendous amount to offer, the unique local combination of NFFTI and ONR MidPac Office resources, in conjunction with other centers -- many if not most of which have strong congressional support (some are dependent upon it, albeit many are striving to become self-sustaining) -- would seem to offer a major opportunity for ONR to play a much stronger role in enhancing regional cooperation and building trust and interoperability among nations in the Asia Pacific region. As issue is ONR's interest in accepting this responsibility, and associated tasking and resourcing of the new office.

Itinerary:
7 July, Saturday: Travel home - SFO; Halfmoon Bay; RON Doubletree
8 July, Sunday: Visit Muir Woods and coast N of San Franscisco
9 July, Monday: Keynote address, PACON 2001
10 July, Tuesday: Arrive from San Francisco; RON Lockwood Hall BOQ
PM: Mid Pac office with Gary Jensen, Fred Kuster
11 July Wednesday: AM: COMSUBPAC; Staff, SciAdv Steve Basile
Lunch with Science Advisors, Hickham AFB
PM: (1) Center of Excellence for DM/HA, Trippler Medical Center
(2) DV ride on SLICE, Dick Porter host
12 July, Thursday: CINCPAC: DCINC, J50, J45 staffs; SciAdvs Mike Reilley CINCPAC and Ashley Johnson, FMFPAC
Eve: Dinner with MidPac Science Advisors and wives, Indigo Restaurant
13 July, Friday: AM: (1)CINCPACFLT: DCINC, SciAdv Fred Kuster
(2)International Pacific Research Center; Dr L. Maagard & staff
PM: SOEST Institute of Marine Biology, Dr Paul Nachtigall
Evening: Fly to Maui; RON Outrigger Wailea
14 July, Saturday Eve: Dinner with Ted Sheppard, Bob Dent, MHPCC, Tommy Bahama's
15 July, Sunday: Interviews with University of Alaska Search Committee, Dave Veazey
16 July, Monday: AM: Drive to Haleakala, visit MSSS, Joe Janni & Capt Josh Snodgrass, AFRL

PM: (1)PDC w/Gary Jensen, Joe Janni: Dir Joe Lees, Craig Chellis
(2) MHPCC w/Gary Jensen & Joe Janni; Capt Dale White
Evening: Dinner w/Gene & Beryl Bal, UH/MHPCC Director, Wailea Golf Club

17 July , Tuesday: Transit to Tokyo, arrive 18 July; RON Ryokan Shigetsu, Asaku

Report 3: 18 July - 4 August 2001: Japan
A: Observations re Japanese S&T
B: Japan Visits
C: Opportunities and Comments
Itinerary
Addendum: S&T Policy

A: Observations re Japanese S&T

This is a period of dramatic change for Japanese S&T. In 1995, the Diet passed the S&T Basic Law, which required two successive five year plans and promised to double the S&T budget. Under the first of these plans (1996-2001), the budgetary target was met -- total outlay over the past five years has been 17T Yen -- and a number of reforms intended to increase Japanese contributions to basic research were implemented. Japan is now entering the second five-year S&T Basic Plan, with planned spending levels of 24T Yen over the next five years, albeit tied to the economy, plus additional reforms. These are accompanied by major structural changes in the S&T management and execution structure, some of which took effect at the start of 2001, and others that will take place over the next few years[1].

In brief, some of the more significant changes (details are available at the IFO – we were given brochures that spell out many of them)

- The Council for Science and Technology Policy (CSTP) has become one of four committees within the Cabinet Office as of 1 January, advisory to the Prime Minister (no such organization or coordinating mechanism existed before)[2]. It has recently issued a plan to give priority in S&T to Life Sciences, Information and Communications, Environment, and Nanotechnology and Materials (with 4 other areas "crucial to national security": energy, manufacturing technology, social infrastructure and 'Frontier Areas") in the allocation of 2002 budgets (which process is now underway). The Council is also conducting a review of all aspects of S&T policy.
- The former Education and S&T ministries, Monbusho and STA, have been combined into a single Ministry of Education, Culture, Sports, Science and Technology (MEXT)
- Government Laboratories (e.g., the previous MITI's AIST, the Agency for Industrial Science and Technology), have become "independent administrative organizations" (e.g., AIST is now the National Institute for Advanced Industrial S&T), principally funded by but independent of the Ministry of Economy, Trade and Industry (METI, formerly MITI), with both major reorganizations and the ability to determine how to allocate their funds
- METI is encouraging technology transfer via the establishment of small companies and collaboration of academics with industry (before 97 this was not allowed). In a sense, now, S&T support is viewed as "infrastructural" spending (like transportation and construction, both of which have been fueled by the government), albeit there is considerable debate about how to evaluate its impact.

[1]For more information on the reforms, the rationale behind them, and the Second S&T Basic Plan, as well as other Japanese S&T items of interest, see the NSF Tokyo Policy reports, which can be found at http://www.twics.com/~nsftokyo/trm.html

[2]As Bill Blanpied, NSF Tokyo notes, The Cabinet Office itself is an inovative creation rather analagous to the Executive Office of the President in the US. For the fiurst time, the Japanese Prime Minister has an office with an extensive staff that should permit hiom to get his arms around the entire government.

- Public Corporations, such as JAMSTEC and NASDA, (non-government employees but funded by government agencies), have not yet been structurally changed, but obviously will be influenced by the Council's priorities, and are under review.
- In 2003, National Universities will (most likely) become independent (Professors and technicians will no longer be government employees [although flat-level salaries are guaranteed for 5 years] and the Universities will be able to decide on their own, without Ministry approval, to start or stop programs), albeit the number of students and tuition levels will remain under Ministry control.

While most of these major changes are so new that it is too early to assess their long term impact, they are naturally causing considerable discussion and debate. In general, they are aimed at reducing redundancy, enhancing cooperation among the various sectors of S&T (e.g., Universities and agencies or research institutes, which have historically operated with near zero interface), providing more coherence and strategic direction across the very large and capable Japanese S&T enterprise, and encouraging and exploiting indigenous innovation in research, in much the same way that Japan successfully exploited (in what some called a 'free ride') western science before and during the 'bubble' years. Perhaps as importantly, these changes in S&T policy and structure are not isolated, but rather are just part of a number of major reforms that increase the power of the Prime Minister and his Cabinet and the accountability of politicians, while reducing the power of the bureaucracy.

On top of all this, of course, is the 'recession' and significant anticipated economic reform and associated 'pain'. Major S&T endeavors that are not near completion may well be jeopardized, and it is unlikely that any new initiatives outside the priority areas (and probably few major new ones within) will be supported. Thus in spite of the proposed overall increase in S&T funding (again, tied to GDP and GDP growth), I believe that financial retrenchment in areas such as facilities and major instrumentation can be expected, in contrast to the large outlays of 'supplemental' support which have fueled many of the major infrastructure programs over the last several years (e.g., at JAMSTEC, the 'supplemental' budget in 98-00 was 653M Yen, compared to a Base budget [including salaries] of 910M Yen; this went largely into new buildings and equipment, including the Earth Simulator). And, of course, the details of Prime Minister Koziumi's economic reform plans have not yet been seen, and the degree of pain the Japanese public is willing to tolerate (especially in areas like construction) is unknown.

Further, while most interest and attention is focused on the badly needed economic reforms, there is also discussion about changes in roles and relationships of the Japanese Self Defense Forces. While Constitutional (and SOFA) changes seem unlikely, there are a number of lesser actions, based on constitutional interpretation or policy decisions; and some of these will almost surely occur within the next few years. Of particular interest for DOD-related RDT&E, much of the debate centers around the issue of "collective" vs "minimum" self defense. Basically, the JSDF now partners with, and will transfer of military technologies to, only the US; and will not export arms (i.e., anything that goes into a weapon system or military equipment), even to us. Thus technology that results from US-Japan defense cooperation cannot be passed on to other US allies. And even more importantly, these restrictions combined with the overall Japanese 'isolation' of the Self Defense forces severely limit not only US DOD but also Japanese access to Japanese commercial and academic technology. Fundamentally at issue is the role of 'military' forces in the 21st century, as Japan seeks greater international status and as tasks like HA/DM, SAR, CT/CD, etc, become more important.

While many of the reforms described above may not seem earthshaking to those not familiar with past Japanese S&T Ministries and their practices, to those of us who are, they are indeed dramatic both in scope and in style, and will in all likelihood (as intended) change the fundamental structure of S&T in universities, government and quasi-government organizations, and industry. As just a couple examples: the Japanese historically have been loath to set priorities without extended discussion leading to consensus, since picking winners means making losers. The new system is firmly based upon top-down mandated prioritization, both overall and within agencies. It also significantly increases the amount and nature of competition, while enhancing mobility by both positive incentives and removing many employment safeguards. Further, in the past, Ministries were unable to fund work outside their own agencies and institutes, and their employees (including professors at national universities) were likewise unable to access resources from any but their own ministries and agencies. Thus interaction and information or infrastructure sharing was essentially blocked; e.g., scientists at University of Tokyo's Ocean Research Institute (under Monbusho) couldn't do science from JAMSTEC's ships (under STA). These barriers are now broken down, and while it will take time to change old habits, at least logical collaborations are no longer ab initio precluded. Similarly, industry-researcher collaborations are now encouraged and rewarded, while before the new reforms, most such interactions were prohibited.

As noted above, the reforms are just now kicking in; and I have given only a very cursory description of them (the IFO has details), and focused just on those related to S&T. The S&T ones are however crucial, since Japan's economy in the recent past and in the future has rested and will rest heavily upon their technological capabilities, and they fully recognize that drastic change will be necessary if they are to retain their status as a dominant economic power. Indeed, I believe that **the changes they are trying to implement are crucial to the future of the nation**. At issue, therefore, are how well they can carry through on their intent of stimulating and exploiting their intellectual and innovative capacity, and whether they have made the right choices in the priorities they have selected. They seem, for example, to be banking heavily upon IT. But IT is a highly competitive field globally, and market size for many of the envisioned future capabilities depends upon progress (and life style choices) in the world's developing nations; not the least of these is China, and China is moving very fast in the same technological direction, with many competitive advantages. And, from the standpoint of reform implementation, it is open to debate whether they have done enough to eliminate past legal and regulatory barriers to collaboration and innovation, and whether they can now take advantage of some of the new opportunities. I give a few additional examples of residual concerns below.

In addition to reform of its own systems, Japan also faces challenges in its S&T relations with other nations. It has many bilateral relationships, at many levels (Ministries, agencies, institutes, individuals). It has, however, very few multilateral ones, albeit there are signs of movement in that direction (not the least being discussion this week of new security relationships among the US, Australia, Japan, and Korea). And, it has yet to play the leadership role of which it is capable, in areas where Japan has technological capacities above those of its Asian neighbors. JAMSTEC's underutilized ships and deep sea research systems are one example; another was provided at NASDA, where a recent international review panel suggested Japan take a leadership role in earth observations, rather than spreading its resources across too many areas.

In industry, although increased unemployment in the near term will be an inevitable result of economic reforms, in the longer term Japan faces likely manpower shortages, especially in high technology. There is naturally much concern with competition from China, as well as other SE Asian countries, many of whom are targeting the same sorts of high tech manufacturing that

drove Japan's economic success. Relationships with China and Korea are particularly problematic in my opinion, and though the issues are multidimensional, one need only contrast the remaining differences in historical perceptions (the textbook issue) with the dominance of Chinese and Koreans in the list of international students and researchers at virtually every civilian organization we visited (see below).

In summary, it is indeed a very 'interesting' period for S&T in Japan, and the outcome of the policy changes and government reforms over the next few years will have a very long lasting impact both on the nation's strength and security, and on all aspects of its relationships with the US and its Asian neighbors. It will be very important for us to follow the changes closely, to enhance our long term mutual cooperation and support the moves to multilateralism and openness. Of particular importance in my opinion, Japan has invested very heavily in S&T infrastructure – examples mentioned above and below include the test ship AKUSA, JAMSTEC's ships and vehicles, and the Frontier program's Earth Simulator. Both sides could profit from greater scientific access to these facilities, and the US could play an important role in helping Japan eliminate the barriers to internal collaboration between different S&T sectors and institutions, while ourselves benefiting greatly from effective use of the available and, again in my opinion, underutilized infrastructure.

B: Japan Visits: Following are a few brief notes on some of my visits; I was accompanied on all visits by CDR Pennypacker, Dr Narita, or other ONR IFO Asia reps; they have copies of all the brochures provided by our hosts, and will prepare detailed reports as warranted.

MEXT: The new Ministry of Education, Culture, Sports, Science and Technology (MEXT) combines the previous Monbusho and STA. MEXT was created as part of the reform that reduced the overall number of Ministries and strengthened the power of the PM and Cabinet, in the case of S&T largely through the establishment of the 14-member Cabinet level Council for Science and Technology Policy (one of just 4 such committees), which has its own staff and, as its name states, sets the policy for MEXT and the other ministries that support S&T (MEXT has about 63% of the S&T budget, METI about 15%). Accompanying these structural changes is the new S&T Basic Plan, which is both more strategic (it includes priorities, one of which is promotion of Basic Research, at the insistence of the old Monbusho; plus reforms to increase competition, mobility, and quality) and more comprehensive (including the social component) as well as increasing the 5-year budget to 24T Yen (assuming 1% GDP and 3.5%/year GDP growth…we were told MEXT emphasizes the 24T Yen, while the Ministry of Finance emphasizes the conditions).

Structurally, MEXT has three Education Bureaus, and three S&T/R&D Bureaus. Interestingly, the Education and S&T sectors are housed in separate buildings, at least for the time being; and, inevitably, there will continue to be arm-wrestling between them. However it is notable that we were briefed by ex-Monbusho folks who are now responsible for S&T policy and international affairs. At issue therefore is whether MEXT will indeed be able to break down the old M/S barriers, or whether the new overlay will merely be a shell containing the two residual sets of bureaucrats. The former seems much more likely (indeed almost assured) given the direction in which the country is moving, so it is more an issue of timing and thoroughness of integration, rather than whether it will indeed happen (there are some interesting parallels to the transformation from the 6.1-only ONR to today's S&T organization…lets hope they do better).

Another interesting part of our discussion centered upon the universities and research institutions under MEXT. We were told, for example, that the Committee dealing with the transformation of national universities into independent institutions has indicated that it will reach a conclusion by the end of 2003; but MEXT has already announced its intention to implement

this transformation. Previous National Research Institutions have already become Independent Administrative Institutions, and while there has yet been no change to the "Public Corporations" (the distinction between this designation and IAIs seems unclear to everyone), there is considerable discussion about the status of the three separate space agencies, and even some about integrating JAMSTEC with ORI or the National Institute of Polar Research. The bottom line is: expect yet more changes, focused on quality, mobility, and integration.

Interestingly, at the end of our briefing at MEXT, I was asked for my views on the most significant weaknesses in the Japanese science system. I gave three. The first is the separation between engineering (old STA) and science (old Monbusho) – the example being the inability of University scientists to work on JAMSTEC ships. This has truly crippled their progress, not to mention requiring redundant investments. At least in experimental sciences, the two have to go hand in hand; and the fundamental, if not cultural, barriers to fixing this seem to be in progress. The second is the hierarchical system in the Universities: each "lab" has one Professor, one Associate Professor, one or more Assistants or Instructors. And, the Professor calls all the shots on what gets studied, and gets his name on all the publications. Thus we see less than desirable stimulation of the intellectual drive of new scientists, lack of mobility, barriers between labs, little intellectual interchange between very narrow specialties let alone disciplines, etc., etc; and I don't see any of the reforms, yet, touching this debilitating. The third major weakness is the isolation of national-security driven S&T. This problem will be hard for Japan to deal with given its WWII-dominated historical focus, but modern military missions including responsibilities such as disaster management and peace operations, plus the inherent similarities between 'security' and 'civil' technologies, to me at least imply that change will be essential. And, in my opinion it will be at least as important for MEXT and other Ministries to understand and support such needed change, as it will be for the JSDF to argue for a more legitimatized role in Japanese society.

JSPS: The Japan Society for the Promotion of Science is a 'quasi-governmental' organization (all funds from MEXT, though independent), and essentially functions like NSF. It was founded in 1932, and underwent a major change in 1999 under the First Basic Science Plan with the infusion of 82B Yen from Monbusho, partly in anticipation of the changes which led to MEXT. Basically, JSPS manages competitive grants to individual university scientists, in a bottom-up, peer-review, proposal-pressure based funding allocation manner, while MEXT is responsible for the "big" and "targeted" or strategic programs. There is apparently great demand for JSPS support, since we were told that success rate is about 16%. In addition to its competitive programs for Japanese University scientists (Grants in Aid, and Research for the Future which is intended to stimulate university collaboration with and formation of venture SMEs), JSPS manages fellowships for young researchers and international scientific exchange. Its long list of exchanges is dominated by China and Korea, each of which have about three times the activity of the US (US exchanges are somewhat less than those with Thailand!). Of particular interest to me was the availability of short term individual fellowships (7 to 90 days for US; NSF is the implementing agency for all US exchanges[3]) which can be very effectively used for planning.

Although almost all of JSPS's international programs (exchanges and seminars) are bilateral, there are two small multi-lateral programs with ASEAN nations, in biotechnology and (notably) coastal oceanography (funded by overseas development funds and thus limited – but, we were told, additional participation at own expense may be able to be discussed). And last year, for the first time, with the assistance of NSF, JSPS ran an ASI-like multinational seminar on robotics.

[3]See http://www.twics.com/nsftokyo/home.html

AIST: Under the new system, MITI's internal Agency for Industrial Science and Technology has become the METI-funded autonomous (i.e., gets targets and most of its funds from METI but itself determines how to meet the targets) National Institute of Advanced Industrial Science and Technology (thus retaining its acronym). Of all the organizations we talked to, this one has had the most radical reform. AIST can now get funds from private sources (we were told its goal is 30% from industry), get and transfer IPR (but not for equity interest), and assign, fire and hire its own staff (it has both tenured and limited term 'Permanent' Researchers, with the latter category growing; plus a comparable number – about 2500 – Visiting Researchers from universities and industry). Fifteen previous Research Institutes have now been merged into one. In turn, AIST has totally reorganized its research units. It now has 23 Research Centers, each of which has a short-term (3-7 years) mission oriented goal and top-down management, with an average of 10-20 AIST researchers and about the same number of visitors; 22 Research Institutions which are long-term basic and applied research oriented with bottom-up management (50-100 AIST and a similar number of visitors); 7 Research Initiatives that respond to government needs and are incubators for new centers and the Institutes; and 2 Special Divisions.

The research units compete within AIST, and are reviewed periodically. Although overall AIST government funding is secured until (but just until) 2005, it is firmly expected that some units will succeed and others fail. While a few of them must carry on national functions of the previous separate Institutes (e.g., geological survey and metrology), most are directly focused on the priorities set out by the Council on S&T Policy, and must demonstrate that they make a difference. We were shown a matrix that demonstrates the alignment. Two other points of note: AIST's President, Hiroyuki Yoshikawa, is also President of JSPS, President of the Science Council of Japan, heads the new Science City, and is a "Head of Administrations Concerned" member of CSTP, appointed by the PM (and he likely has several other positions; to me, this is a hangover of the 'old' system; no way can any one human reasonably be expected to effectively administer so many diverse groups, nor should he given their inherent conflicts. I don't know the man, but no matter how good he is, I have my doubts about the rationality of placing such a broad operational and organizational mandate under a single bureaucrat). And, like in JSPS, the roster of international visiting researchers is dominated by Chinese and Koreans, with the US coming in slightly behind Thailand! AIST will be very interesting to watch: many of its research units are pursuing S&T of significant interest to us, it has good and growing links to Japanese industry, and it is a most interesting experiment in radical reform that could hold many lessons for the universities and agencies of MEXT.

TOSHIBA: We visited the Toshiba Science Institute…along with several hundred school children. Super show, very impressive both from the standpoint of what they're doing in S&T (especially in IT with a focus on wireless networks, systems and services; and in the number of manufacturing and sales offices in China and SE Asia), and as an example of a typical major Japanese Corporations' efforts to 'promote' their S&T through an "Institute", which is really an interactive science museum – established in 1961, and about 120K visitors per year. This Institute is well worth a visit both for the professionalism of Toshiba's PR/outreach, and for the insight into Toshiba's overall business and attitude to the public. However…their Corporate Research Lab, which was next door, we did not visit; not did the video about R&D have much to add to the basic video about the company. As with other Japanese corporations, that dominate their national S&T investment, there is undoubtedly much that is of great interest to us, yet remains 'inscrutable'. At issue is how to access it, in particular given the isolation of the self defense forces and the prohibitions about arms exports.

JAMSTEC and YES: JAMSTEC, like NASDA, is a Public Corporation under MEXT (previously STA). Doug Edsall has already written a report on this visit, and JAMSTEC is in

general well known to US investigators, so I will make only a few brief comments. First, Japan's investment in ocean research infrastructure through JAMSTEC has been extensive and of long duration. JAMSTEC has excellent engineers that have developed many innovative seagoing systems, plus access to exceptional industrial technology. Changes since my last visit (in the early 90's) have included a beautiful new headquarters building, the Deep Sea Microorganism System which has perhaps the world's best capability for maintaining and studying marine extremophiles, several new AUVs and ROVs, two new ships (KAIREI with the 11,000M ROV KAIKO, and MIRAI), a number of offshore observatories, and the new Mutsu Institute for Oceanography. Soon to come are the new deep sea drilling ship CHIKYU, and the Yokohama Institute for Earth Science (YES) with its quite astounding Earth Simulator (40TFLOPS throughput vector-parallel computer – the first nodes were being installed when we visited). The investment in marine science infrastructure, using both base and supplementary budgets, has been absolutely astounding…particularly when you consider that JAMSTEC has only 244 regular employees. These resources beg for exploitation. I will comment on this in section C.

NASDA: We received a very thorough and open briefing on NASDA's status and the impact of recent changes. NASDA is at the moment a 'besieged' agency (basically, although the public is not negative toward space, there is likewise no strong support) given the failure of its last two rocket launches (much as NASA was after many of our own difficulties); and it is very focused on succeeding in its upcoming third attempt. Beyond that, it is dealing with two major issues. The first is response to the recommendations of an international review panel that was called in 1998 by its former President, Isao Uchida, and which just this March reviewed progress. Basically, NASDA has been trying to do too much with limited resources, and has to prioritize; and as part of this, it should take an international leadership role in some area of expertise, e.g. earth sensing, with a focus on Asia. This would, besides providing a manageable space target, couple well to Japan's other ocean capabilities, and address the CSTP priority areas of environment and Frontier topics. But to repeat, prioritization is new, and hard, in Japanese S&T.

The second issue for NASDA is the overall Japanese structure for space development. The previous Space Activities Commission, which provided guidance for all space activities, has now been relegated to MEXT; it has been superceded by CSTP, which however has yet to take a firm hand in this arena. And, there are three major space agencies – NASDA which is a Public Corporation that gets support from MEXT and two other Ministries (transport and telecommunications), and the National Aerospace Lab and Institute of Space and Astronautical Science, both of which are under MEXT. And, although it is not at the moment a topic of discussion, space activities no matter how peaceful in intent have inherent implications for national security, and sooner or later this will have to be resolved. As our briefer said, the Japanese space program, and NADSA in particular, is 'under construction'.

TRDI, JDA: In addition to receiving an in-depth briefing by the US Chief of MDAO, we visited the Japanese Defense Agency's Technical Research and Development Institute, and it's 5th Research Center (Yokosuka), which is responsible for sonar and underwater weapons. TRDI is a 'purple' organization, albeit with Ground, Naval, Air Systems and Guided Missile Development Departments; each component of the JSDF also, we were told, pursues some of its own developments. Given the restrictions on JDA activities and on technology transfer, plus the close relationships with the US, there is a very active MDAO program in both FMS and DCS, as well as many DEAs and cooperative R&D programs. Nonetheless there is a strong seam of Japanese self-reliance and desire to support the indigenous industrial base (mostly the major companies; albeit they basically 'fence' their defense activities from their commercial programs) and indeed there are several Japanese developments in which we have significant interest. We received a brief on the Shallow Water Acoustics Technology Cooperative Research Program between TRDI

and NRL (with WHOI and U. Miami participation), notably from Dr Ohta who received his MS and PhD (93) at MIT/WHOI respectively under Ira Dyer and George Frisk. While I need not comment on SWAT, I mention it because I believe that follow-on efforts should be pursued, given Japanese interests and capabilities in shallow water acoustics. Of particular interest is the 1.5Khz hull mounted sonar on the electric propulsion test ship AKUSA. IFO personnel have reported on that ship (notably its architecture and engineering), but from what I understand we have not participated in or observed its operations; and the performance of that sonar, which our TRDI briefers claimed was very good, should be of significant ONR interest.

University of Hokkaido: Dr Narita and I visited two Professors at the Institute of Low Temperature Research (categorized by MEXT as an "Attached Institute for Joint Use"). This Institute was founded in 1941 by Prof Nakaya, the first person to generate artificial snow crystals. Prof. Wakatsuchi (currently the Institute Director) and his colleagues study ocean dynamics in northern seas, and recently hosted a conference that focused on the results from three years of research in the Sea of Okhotsk (Lynn Talley of SIO and Steve Riser of UW were NSF supported PI's in this US-Japan-Russian joint effort). Prof Hondoh, previous Director, described the overall program of the Institute including its extensive work on permafrost and its changes in Siberia. There are four main groups studying marine and atmospheric science, the cryosphere, basic low temperature processes, and boreal ecosystems. They have maintained an observatory in Mombetsu for 30 years, both to study sea ice and its impact on structures and ships, and to provide information on ice characteristics (using radar) to fishermen and tourist boats. The ice records show some interesting decadal variations, plus an overall decrease in mean ice coverage. Prof Hondoh also described his own research on ice cores, emphasizing the formation and characteristics of air hydrate chathrates. His storage (-50°C) and analytical facilities are outstanding, as is his science.

C: Opportunities and Comments

ONR has reason to be proud of its Asia IFO office. It is extremely well run and managed, and beautifully outfitted. The decision to station a Military OIC in Tokyo was correct, and CDR Pennypacker has done a superlative job. He is properly focused on S&T policy issues and upon improving coordination with MDAO and S&T staff at the Embassy, and with the SAO community throughout the AOR. I have been provided absolutely superb support. In addition, the ADs all seem to be doing a very good job. Dr Narita's contributions are exceptionally noteworthy, and he works very well with Dr Koenig so that we have an excellent team on ship technologies; likewise a very strong team in materials. I do have several comments.

- ONR should maintain its Asian headquarters in Tokyo. Communications are excellent. Living and travel are satisfactory if expensive, and most importantly Japan is our closest Asian ally and the source of exceptional technology. A Japan focus will be particularly important as the reforms take effect and as Japan itself becomes more international; especially noteworthy are its relationships with and access to Russia, China, and Korea, as well as its growing interaction with ASEAN.
- The tri-service members at the office are intermingled, and seem to work very well together. Even more than in London it is foolish and wasteful, as well as frequently counterproductive in relationships with other US staff and with international partners, to maintain three separate administrative structures.
- Language capability is important. IFO Asia staff should be selected with this in mind, and when they do not come with language training should at least be sent to the local Berlitz or other language school for 6 weeks or so of immersion training upon arrival. There is an inevitable stand-up period for any overseas assignment, and this period would

be best utilized in improving the interaction skills of the scientists and administrators. ROI in terms of ability and quality of life should take much less than even the first year of a minimum length tour.

- Staffing policy need not be the same as for London. First, the military services are truly integrated (except again for command and administration). Second, it takes considerably longer to develop ties to researchers and research units than in Europe. I strongly recommend that ROPOs be encouraged, since affiliation with local researchers opens many doors in addition to the normal benefits of the program. During this trip I benefited greatly from having had contact with Japanese science for some 40 years, and from being able to renew friendships with my previous colleagues, may of whom are now in senior positions. Also, extended tours for senior scientists (as opposed to those for whom this would be a growth tour) should be considered.
- Local resources should be exploited to enhance the office's reach and depth. Retired Japanese academics and industrialists could provide invaluable insight and contacts. I found it easy (with the help of Drs Narita and Blanpied, and CDR Pennypacker) to get a synoptic picture of top level issues. It is also relatively easy to talk to individual researchers, or to understand individual programs. However it is very time consuming and difficult to 'scope' the bright spots across an institute or university (and there are hundreds worth exploiting that we haven't hardly touched even after all these years), and access to industry, even the isolated defense sector, without help is extremely difficult.
- Another excellent cost-effective source of assistance is ATIP. We get very good value for money from our current support. One technical area where they could help us greatly (throughout Asia, not just Japan) is optics and optoelectronics. This is a dynamic field we do not now cover from any service. ATIP can get us more, faster, that any other way I can think of.
- I believe that it will be very important, particularly over the next few years, to closely follow developments in Japanese S&T policy and structural change. As I discussed above, this is a crucially important period in Japan's economic and cultural transformation, and effective S&T collaboration in the future will depend on our ability to understand their strategy, their problems, and the opportunities. The same goes for their S&T interactions with Asian neighbors, in particular China and Japan. I believe that following these trends and changes should be the primary 'technical' focus of the OCI; and I believe that ATIP could be very useful as a resource in this area. In particular, I was very impressed by Ms Miwaka Waga's grasp of the issues, and contacts. She is a SPRU graduate, and a senior member of the Tokyo ATIP staff. Frequent briefings by and discussions with her would in my opinion be well worth the minimum cost. Dr. Narita, who is well known and highly respected by many of the Japanese involved in policy formation, could also be very supportive in this area, should his primary assignments in ship technologies permit him the time to assist here.

We can do much to improve our access to Japanese facilities and programs. Of particular note are the international fellowships offered by JSPS (coordinated by NSF) that go begging for lack of US applicants. The 7-90 day visit fellowships should be particularly useful for POs and PIs that have interest in particular aspects of Japanese S&T.

In the same vein, but of even greater significance, are the exceptional Japanese facilities for earth science at JAMSTEC (and potentially NASDA). These include their ships and vehicles, the earth simulator, the deep benthic facilities, their deep sea observatories, the new oceanography institute at Mutsu, and the new drill ship that will have a 4000M riser capability. I am told that Dr. Neureiter has already started to discuss increased US-Japanese cooperation in global change S&T

with his colleague Dr Imura, full-time member of the CSTP and former President of the University of Kyoto (and co-chair with Norman of the US-Japan dialogue Group that developed "An Agenda for Future US-Japan Scientific and Technical Cooperation", May 2000), in anticipation of a visit to Japan by President Bush. If the US approach to global change is going to emphasize S&T, then enhanced collaboration with Japan, given its historical and continuing focus on the environment, as well as its world class facilities and excellent researchers, would be only logical. There are similarly many opportunities for enhanced cooperation in cleaner energy systems; and in this instance, Navy shares an interest with other US agencies and with Japan in methane hydrates. I strongly recommend that ONR discuss with the Office of the S&T Advisor to the Secretary of State, ways that our mutual agendas can be advanced by enhanced US-Japan collaboration in marine S&T.

Another Japanese resource with which we should pursue additional collaboration is the test ship AKUSA. A follow-on to the current SWAT program may be worth considering.

Itinerary

July 18, Wednesday: Arrive Tokyo; RON Ryokan Shigetsu, Asakusa
19 July, Thursday: IFO Office, AD briefs; ATIP (Ms Waga)
20 July, Friday: NSF Roundtable (Bill Blanpied), IFO Office, AD Briefs
(Japanese National Holiday)
21 July, Saturday: Ueno Park, Tokyo National Museum
22 July, Sunday: Transit to Yokosuka, RON BOQ Togo Room
23 July, Monday: JAMSTEC meetings and tour (President Hirano; Exec Dir. Chijiya)
24 July, Tuesday: Yokohama Institute for Earth Sciences; Earth Simulator, Frontier Research System for Global Change (Dr Matsuno), Frontier Observational System for Global Change (Dr Hotta)
25 July, Wednesday: Courtesy Call CNFJ, RADM Chaplin; transit via Haneda Airport to Sapporo, Hokkaido ; RON Iceberg Hotel
26 July, Thursday: University of Hokkaido: Institute of Low Temperature Research (Prof Wakatsuchi), Graduate School of Engineering (Prof Saeki)
27 July, Friday: University of Hokkaido: Institute of Low Temperature Research (Prof Hondoh)
28 July, Saturday: Sapporo, Historical Village of Hokkaido
29 July, Sunday: Bittori, Hokkaido, Ainu Culture Museum
30 July, Monday: Transit to Tokyo; ONR IFO; RON Shigetsu Ryokan
31 July, Tuesday: MDAO Brief, Embassy Roundtable w/MG Bolton (COL Yauch & staff), Courtesy Call VADM Takeda, Dir Naval Systems Dev't, TRDI; TRDI Brief
1 August, Wednesday: Toshiba Science Center; TRDI 5th Research Center (Dr Komatsu, Dr Ohta)
2 August, Thursday: w/NSF Bill Blanpied: MEXT (Mr Inoue, Mr Mori); JSPS (Mr Nakanishi); METI - AIST (Dr's Kamimoto, Miyamoto, Kitano); NASDA (Mr Kisshu)
3 August, Friday: report preparation, ONR IFO; evening, Policy Dinner (see Report 3A)
4 August, Saturday: Transit to Korea

Addendum:
Japan: S&T Policy

One of my principal recommendations regarding Japanese S&T is that we closely follow changes in policy and structure for at least the next few years. This recommendation, based upon my conclusion that revitalization of S&T, as an adjunct to economic reforms and other government changes, is crucial to the nation's future, was reinforced during a dinner on 3 August, the evening of my departure, after I had completed my preliminary report. In addition to Cynthia, myself, and Dr. Narita, attendees were Toshio Yamagata, Professor at the University of Tokyo and a Director of the Earth Frontier Research Center (noted for his recent discovery of the Indian Ocean Dipole which has a major effect on South and East Asian weather); Hajime Mamiya, since January this year Director-General of the National Institute of Science and Technology Policy (NISTEP), MEXT; and Mr. Miki, Executive of JAMSTEC's International Relations Department. I have known Mr. Miki and Mr. Mamiya for several years, notably when Mr. Mamiya was the Director of JAMSTEC's Planning Department.

First, a couple additional notes about the Council for Science and Technology Policy (CSTP). It is one of only 4 such councils. The others deal with Economic and Fiscal Policy, Central Disaster Management, and Gender Equality. Thus S&T is clearly one of the top priorities of the Japanese government. CSTP is chaired by the Prime Minister, has a total of 14 members and is supported by a Cabinet Office, as well as NISTEP. The Ministers of State, Chief Cabinet Secretary and S&T Policy, are statutory members; all others are appointed by the PM. These include the Ministers of Public Management, Home Affairs, Posts and Telecommunications; Finance; MEXT; and METI. The eight others are Dr Yoshikawa, President of the Science Council of Japan, and seven "Excellent Learned Persons concerning S&T" from universities and industry, four of whom serve full time. CSTP's mandate includes humanities and social sciences as well as natural and engineering sciences. In addition to setting basic policy, it establishes resource allocation policy and evaluates large, 'target' projects and the activities and results of MEXT and the other S&T affiliated Ministries.

CSTP therefore provides basic policy direction to, and overall coordination of, MEXT and the other Ministries with S&T responsibilities. Within MEXT there is a Council for S&T, again chaired by the PM, with 10 members. It helps the Minister in his responsibility to formulate, and coordinate with other Ministries, concrete plans and policies founded upon the basic policy from CSTP. MEXT also promotes and evaluates R&D in the areas prioritized by CSTP, and reforms the S&T system within the S&T execution organizations within its purview (previously those of STA and Monbusho, i.e. the public universities, public R&D corporations, and the newly independent administrative institutions), which account for almost 2/3 of the national S&T budget.

NISTEP is administratively within MEXT. It has a staff of 54 (38 researchers). It conducts Foresight surveys and studies various aspects of S&T to help policy makers formulate and understand the effects of their policies (e.g., effect of investments, personnel systems, S&T literacy, regional programs), helps design evaluation systems, and coordinates with similar overseas organizations (e.g., OECD, EU's IPTS). It provides results and advice to CSTP as well as to its parent Ministry. Mr. Mamiya was appointed to the position of Deputy-General of NISTEP in January 2001, i.e. right at the start of the new S&T administrative structure.

In our discussions and NISTEP literature, Mr. Mamiya emphasized several points:
- "S&T is a vital key to overcoming the various issues Japan is facing today, and to open up new possibilities for Japan in the future…"
- Perceptive policies for promoting S&T are essential if S&T is to contribute, as it must, to the nation's future.

- A key component of the policy is promotion of excellence. Thus, for example, the Plan calls for promotion of basic research, and a goal of 30 Nobel laureates in the next 50 years (in this light, Prof Yamagata noted that "all Professors are equal" today, an obvious disincentive to excellence).
- Adequate funds are also required, both for their own sake and as a symbol of the importance of S&T to the nation, and the national commitment to excellence. Thus setting the goal of 24T Yen over the next five years was central to the new policy, and meeting it will be very important.
- Objective survey and analysis is essential to the formulation of policy. Thus in addition to its theory and policy oriented research groups, NISTEP established this January an S&T Foresight Center, which immediately conducted a study of the state and future trends in the key fields in the Second Basic Plan (Life Science, Environment, IT, and nanoscience and materials; plus energy, manufacturing, infrastructure and Frontiers). Notably, NISTEP got over 80% response on each round of questionnaires.

Basically, to reiterate, my conclusions about Japan's perceptions of the importance of S&T, and its commitment to both past and future reforms, were reinforced by these discussions with a colleague who will play a very significant role in recommending and evaluating them. I therefore reemphasize my recommendation that the IFO focus much of its attention on S&T policy and strategy, using both available and additional resources. We not only have much to learn, but if we are astute, we can help Japan with its efforts to improve its contributions to the global S&T base while simultaneously availing ourselves of better access to its facilities and researchers. As an environmental scientist I am particularly excited by the opportunities for collaboration in earth, atmospheric, space and ocean sciences, particularly given the US S&T-based approach to environmental change; but similar opportunities exist in many other fields of interest to ONR.

Report 4: 4-19 August 2001: Korea, Philippines, Hong Kong
A. Korea: Observations, visits, comments and recommendations
B. Philippines: Observations, visits, comments and recommendations
C. Hong Kong: Observations, visits, comments and recommendations
Itinerary

A.1. Korea Observations

Korea has changed significantly since my last visit in 1990, and all for the better. The 1988 Olympics apparently were a turning point, and the country followed that period of heavy infrastructure construction with yet more development and a commitment to modernization. The roads are wide and clean, most of the 'knockoff' products are nowhere to be found (respect for IPR), the 'chaebols' have been restructured, FDI is welcome (albeit hard to recapture as Japan restructures and China joins theWTO; and, with more interest from Europe than the US), and the people appear busy and prosperous. The traffic remains very heavy, especially in and out of Seoul, but the countryside is beautiful and it was a pleasure to visit. Yet more ($310B more) infrastructure improvement is planned; first to host, with Japan, the 2002 soccer World cup; and then to continue development of the network of expressways, upgrade ports and airports, add a bullet train to Pusan, and prepare for the train into the North, and eventually on to Russia.

As noted in an earlier report, Korea is now striving to become a significant player in the region, and a more widely accepted global partner. Looking beyond just defending against the North - indeed the major concern regarding the North appears to be the economic impact of eventual reunification[4] - the ROK is focused on its international posture as a modern nation. Navy, for example, is extending its reach to a thousand nautical miles and its missions to include SLOC protection; and the ocean research institutes are designing deep sea mineral recovery systems. The S&T vision is likewise directed outward, with the goal of becoming a leading 'advanced' nation by 2025. At issue seems to be the same question other Asian nations are asking: how to use S&T to reinvigorate the economy, which is still in a post-restructuring stagnation period, particularly in the face of China's growth and burgeoning high tech competition.

As a basis from which to make the desired changes, Korea remains #1 in shipbuilding, and likewise is a major power in steel, construction, power generation, automobiles, and licensed manufacturing; it also competes very well in some aspects of advanced electronics. Korea intends to rely principally on nuclear power and LNG for its energy needs (we were told the major coal mining area has been turned into a casino), and is improving its transportation and energy infrastructure. It is not abandoning traditional strengths, even if investments are focused on other areas; in shipbuilding, for example, it is already noted for customization (minor alterations to basic designs), and is gaining strength in the market for specialized designs and high-end ships (e.g. cruise liners) as China, with cheaper labor, gains more of the 'standard' container ship and tanker market. Essentially, then, Korea's fundamental industrial strengths appear to remain strong; the task at hand is to develop an indigenous science and technology base upon which to expand, in both traditional and new markets.

Korea not only recognizes the large gap between its own S&T capabilities and those of the US and Japan, but has no end of 'plans' to rectify the deficiencies. In some sectors at least the plans

[4] Albeit my USFK threat briefing made it very clear that NK continues to expand its military capabilities even as its economy disintegrates; given these disparate trends it's hard to envision a peaceful and harmonious reunification, barring some major support to that end by Russia and China. ROK is not ignoring this threat, but neither is it in a defensive crouch.

have been followed by significant resources, and Korea changed both its laws and its S&T management structure to better focus investment. They see their strengths (using words from their long range plan) as abundant resources for R&D, the world's lowest illiteracy rate, and high aspirations for education (indeed there is brutal competition for the best education[5]). Korea in general has a well trained workforce, and many of the top R&D personnel have advanced degrees from the US or Europe (and as noted in Report 3, there are many Korean students and researchers in Japan; there may be considerable friction with Japan over the textbook issue, but business and educational contacts have not slowed). These Korean strengths are complemented by a commitment, from the highest levels of the government, to computers and wide-band access to the web throughout the nation (they have actually moved up the planned dates for completing this IT 'underpinning' to other advances), and increased S&T spending (about $12B/year, with recent growth rates of about 15%/year, double that of other parts of the budget, even though the economy remains flat; also, they aim for a 30/70 government/industry R&D expenditure ratio).

On the other hand, Korea cites as weaknesses their S&T management system, "lack of a general awareness of S&T as a major factor for national development", the heavy security burden, and an "immature political, economical, and social environment". I would add as a strength the lack of institutional barriers between academic, government research institutes (GRIs), and industry, and as a weakness the fact that with few exceptions, they haven't capitalized on that opportunity, and have yet to find mechanisms that fully utilize and integrate the abilities of each sector (e.g., they complain that over 70% of their PhDs are in universities, where teaching loads and lack of facilities inhibit their contributions to innovation). Another weakness is gender inequality. There are no women in the Armed Services, and besides the 'tea-girls' and golf caddies, I saw no women during any of my visits to R&D institutions.

A few words about some of the recent plans and the S&T structure:
- Starting in 1992, the "Highly Advanced National (HAN) Plan was aimed at joint government-industry development of strategic industrial technologies and S&T self-reliance in two categories, hi-tech products (e.g., agrochemicals, IT, next generation vehicles and express rail) and fundamental technologies 'indispensable for continued economic growth and high quality of life' (e.g., next generation semiconductors, materials, manufacturing systems, environmental and energy technologies). However, with a total budget of $3.2B between 1992 and 2001, this was hardly enough to make a significant dent in the S&T gap, in most areas.
- the "21Century Frontier R&D Program" is a follow-on to the HAN project. An investment of $3.5B is planned for 20 projects, 10 of which have started[6] (the others will be selected in 2002), again combining basic and applied research, "but with a greater focus on information technology, biotechnology, nanotechnology, and new materials" (quotes from the Ministry of Science and Technology's brochure, *Science and Technology: It is our Future*). Again, however, it is impossible not to compare Korea's relatively minor investment in, say, nanotechnology, with that of Japan and the US.

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[5] The pressure on students is immense. In addition to the direct impact on the students themselves, this can be debilitating from both social and S&T perspectives; since the best education is in Seoul, that's where everyone wants to live to get the best for their children. Not only does this lead to traffic and housing problems, but it means that many men are work-week bachelors, commuting home only on occasional weekends. Institutes in places like the Daedok Valley near Taejun -- which combines a "Science Town", Expo science park, and industrial complex with tax advantages, and has over 100 government, industrial, and venture organizations -- have built barracks for such S&T staff.

[6] The projects or centers are in: human genome analysis; tera-level nano devices; intelligent Microsystems; plant diversity; industrial waste recycling; new drugs and biological modulation; crop genomics; advanced materials; applied superconductivity; and sustainable water resources

- *Vision 2025: Korea's Long Range Plan for Science and Technology Development* discusses, in 197 pages, Korea's strengths, weaknesses, and directions of development. Albeit lengthy, this document should be required reading for anyone wanting to understand Korea's official stance re the importance of S&T to their future. It sets goals for three periods: by 2005 to join the top 12 nations in S&T competitiveness and get ahead of other Asian nations; by 2015 to stand out as the hub of research in the Asia-Pacific Region; and by 2025 to join the top 7 countries in S&T by forging ahead in specific sectors. Six areas are identified for priority in spending and development: information as the basic underpinning capability, life science, mechatronics and systems, new materials, environment, and energy. The Plan also calls for a transition from a "government-initiated and development-focused to privately-led and distribution oriented" R&D system, global networking, more emphasis upon efficient utilization of resources as opposed to simply pumping in more money, a strategic shift to a long as opposed to the past short term perspective, and better national S&T management. This is a very interesting and insightful document; at issue of course is their ability and willingness to execute.
- The Ministry of Science and Technology (MOST), established in 1967, remains the leading official S&T institution. It formulates and coordinates S&T policy, and develops the S&T portion of the national economic plan. On the other hand, even MOST's own documentation is full of criticism of Korea's S&T management system, and to help remedy this in 1999 the government established a National Science and Technology Council chaired by the President, with MOST as the Secretariat, and with technical support by the Korea Institute of S&T Policy Evaluation and Planning (KISTEP)[7]. To improve management of the extensive network of GRIs, many were removed from MOST's control, and placed under NSTC's three new Research Councils: one each for Fundamental, Industrial, and Public S&T. In addition to these agencies and institutions, S&T is conducted by a number of Quasi-Public S&T Organizations, Nuclear-related Agencies and Public Utilities, and an extensive system of National Universities. There appears to be no intent to 'privatize' these institutions, rather to enhance their interactions with each other and with industry. We were told that by the EST counselor that the government does use an effective system of conferences and workshops involving all sectors to help it develop its S&T plans, and that the linkages are indeed improving; although to date - as the Vision document recognizes - the government retains the lead in establishing direction, priorities, and large research programs. Several researchers we visited emphasized that the government is responsible for the high risk aspects of R&D, while Industry is expected to make its major contributions via investment in more secure product oriented developments.
- The Ministry of National Defense has its own tri-service R&D organization, the Agency for Defense Development, established 'for increased self-reliance' in 1970. The services pass their requirements to MND, which approves projects and assigns them to ADD. ADD is responsible for system and key technology developments in its own 5 centers (Ground/CB, Naval, Aircraft and Missiles, IT/EW, and Technology), and utilizes Universities and GRIs for basic and applied research, and industry for production. ADD has established several University/Institute research centers, e.g. for EO at KAIST, microwave technology at POSTEC, and automated control and acoustics at Seoul National University. It also has a new 'Dual Use' center (just 10 people) which sponsors and manages research with funds from a consortium of MND, MOST, MOCIE and MIC (we were given no details). ADD has designed a number of interesting 'precision conventional weapon systems' based on indigenous technology, often incorporating improvements over similar systems that MND previously acquired internationally. They have recently completed a heavy weight torpedo (White Shark), and are working on an indigenous light weight torpedo (Blue Shark). ADD's Technology Center is working on seekers, composite

[7] The EST Affairs office of the American Embassy annually publishes an excellent brochure, *Who's Who in Korean Environment, Science and Technology*, that describes the various offices and GRIs. IFO should request a copy.

materials, propulsion, radar, guidance, data transmission, fire control, and structures (nfi). We visited ADD's Naval Center at Chinhae and its headquarters at Taejun, where we saw their new display room and examples of past , current and planned developments. In general, ADD's projects seem designed to parallel and simply provide indigenous alternatives to many conventional US systems. ADD also supports a number of Cooperative R&D projects (more offered than we have accepted), and places 8 or 9 Korean ESEPs in the US annually.

Although my visits did not provide any significant insights into the details of Korea's S&T developments, it is clear both that the country is seriously committed to reinvigorating its economy through S&T investments at the level of 5% of the federal budget, and that the nation has consistently demonstrated excellence, in some cases dominance, in some very interesting areas, e.g. semiconductors, flat panel displays, steel, ships and vehicles, and power. The weapon systems they produce also seem very capable if much the same in purpose and appearance as our own, and they have had some success in international sales. The documentation provided by MOST and the Embassy provides a good basis for further examination of Korea's capabilities, and -- as with other Asian nations -- it will be important for us to closely follow developments as they proceed to implement their plans and improve their S&T management.

A.2. Korea Visits: With the exception of MOST and MND I visited only organizations with which ONR Asia has had previous contact, and in some cases extensive interaction. Comments on them will therefore be brief.

SNU: Seoul National University's College of Engineering has almost 250 faculty (all with degrees either from SNU, or leading US or European Universities), and over 5500 undergraduates and 2200 graduate students, in 5 Schools and 6 Departments. We visited Assoc. Prof. Shin, of the Dept of Naval Architecture and Ocean Engineering, who described his recent NICOP proposal (joint with U. Mich). I was impressed with both his research on structures, and his lab for shipyard simulation. Prof Shin noted that SNU still is the nation's top ranked university, although in Engineering it has a lot of competition because of the economic importance of engineering training. Some 10 universities have NA/ME programs, though many of them are decreasing in size and combining with other disciplines because the shipbuilding companies are 'saturated'. SNU's Department, however, with about 240 undergraduates and 30 each Masters and PhD students, is retaining its identity. We also had a brief conversation with the Department Chairman, and later learned from the College's brochure that among their Affiliated Research Institutes is the Underwater Acoustics Research Center that was established by MND (ADD) in 1997; it apparently serves more than a hundred researchers, and would appear to be worth a visit.

MOST: As noted above, the Ministry of Science and Technology plays a central role in S&T planning, but a somewhat ambiguous one given criticism of its past S&T management. MOST is responsible for several national programs including HAN and the 21Century Frontier, support of National Research Labs, a Creative Research Initiative, and special programs in Biotechnology, nanotechnology, Space and Aeronautics (Korea plans to establish a space center, develop a satellite launch capability, and launch 17 additional satellites by 2015), and Nuclear R&D and safety (some feel that nuclear development has been underfunded, in part because of US concerns with reprocessing). MOST manages the largest share of the R&D budget (in 2001, ~900B Won, compared to 800BW in MOCIE, 700 in MND, 560 in the GRIs managed by the Research Councils, 515 in MOE, 200 each in rural development and small business administrations, and 100 each in Ministries of Environment and Health). In addition to the several Institutes for which it retains responsibility, MOST also oversees the Korean Science and Education Foundation (KOSEF) which functions like NSF, and KISTEP which provides its technical support to NSTC ,

has planning functions, and is responsible for some 'mission oriented' basic research. MOST is also responsible for international cooperation. Our briefers at MOST provided a good if concise overview of their national S&T system and priorities, as well as copies of their brochure and the Vision 2025 plan.

Naval Forces Development: We paid a courtesy call on RADM Kwon, Commander, Naval Forces Development Command. He is responsible for capabilities of current forces and had no interest in S&T. We also met with Capt Shim, Vice-Commander, Naval Sea Systems Command and his staff. They were very interested in ONR's programs and in improving their understanding of NAVSEA's organization. These offices are located at ROK military HQ in Taejon, about 150 Km south of Seoul.

ADD: MND's Agency for Defense Development is also headquartered in Taejon. We met with ADD's Vice President Park, and were offered a tour of the new display room. Since ADD primarily performs system development and integration, and relies upon universities and GRIs for basic and applied research, its Technology Center, with some 400 staff, would be of most interest to ONR. The Naval Systems Development Center in Chinhae is headed by Dr. Tabeo Shim, who has hosted many USN visitors. This center has about 300 employees in 4 Departments: Marine Technology, Underwater Surveillance (which Dr Shim previously headed), Torpedo Systems, and the Naval Weapons Test Range; but it supports a total of some 1000 researchers including those in industry and academia. NSDC-supported researchers participated in Asiaex, and Center personnel were familiar with other ocean-related ONR programs and area specialists. We received a briefing about their activities, then toured the acoustic test facility (based on NUWC blueprints) and the magnetic labs, and were briefed on the test range. Dr Shim, who speaks excellent English and appeared to be very knowledgeable about Korean marine related S&T, noted that the Directorship is a 3-year term appointment, by the President of ADD. He was appointed Director much earlier in his career than is typical.

KRISO: While in Taejon, we also visited the Korea Research Institute of Ships and Ocean Engineering, which was originally established (under a different name) in 1973, but since the 1999 S&T management reorganization under NSTC, has been affiliated with the Korea Ocean Research and Development Institute, KORDI. After an introductory briefing by the DG Dr. Lee, we toured the tow tank and the very impressive 'harbor and waterway safety assessment (bridge and port) simulator'. Dr Koenig has visited and lectured at KRISO, and also has toured their new ocean engineering basin and cavitation tunnel. KRISO has a staff of about 100, and is supported about 1/3 by industry; they perform CFD/EFD tests of hulls for those shipyards that lack their own facilities. They claim a good capability to select the best hull form among alternatives using their WAVIS software, and good agreement with test tank measurements. They are also developing ROVs, notably for deep sea manganese nodule recovery.

MND: I had the opportunity at the end of my visit to call on senior R&D representatives of the Ministry of National Defense. Before my visit the JUSMAG rep passed me three questions from them: What is our budget for cooperation with Japan, can I provide any specifics about our cooperation with Japan, and in what areas is ONR interested in cooperation with Korea? My answers (we don't have such a budget, I don't have details but we do have programs in materials and ship technologies, and the priority list from the ONR IFO brochure) must have satisfied them, because the issue of Japan never came up in my office calls. Our meetings at MND were, however, interesting. After formalities, discussions with the Director, R&D planning focused on my description of ONR's approach and interests (they're more used to DEAs, and to US labs being somewhat reluctant to participate in Cooperative R&D programs they suggest), and my

emphasis on wanting to understand how MND priorities and investment strategies correlated with those we had learned about from MOST. I had been told that MND has previously told US counterparts that their S&T plan is classified, or not ready. I had no better luck, although my host noted that he would study the brochure and slides I left, and get back; in part, I think that after my week's activities, I had at least as good a grasp of how ADD works with universities and GRIs, and of national priorities, as did they. Conversations with MG Yu were pleasant; his approach, at least initially, was on US helping Korea in S&T, while I countered with emphasis on areas I had seen where we could mutually cooperate for both our interests, based on Korean expertise and skills that equal or in some cases exceed our own. We also talked about Korea's broadened commercial and security interests as the nation adopts a more global stance. After those meetings, I was reminded that progress with the Koreans comes one small step at a time, and that our relationship has for years been one of us telling them what to do; the concept of equity, especially in S&T where they are well aware of gaps, is somewhat new.

A.3. Korea Comments and Suggestions:

Additional effort to follow Korea's progress in implementing its national strategy, to try to improve our understanding of MND's priorities and their relationship to other national goals (e.g., what might be MND's interests in a national satellite launch capability?), and to improve our access to organizations and capabilities of known (or likely) excellence, are warranted. As one of the experienced JUSMAG FAOs noted, Korea doesn't set goals without fully intending to achieve them. Their documentation, and the discussions and briefings I had during my week in Korea, are ample evidence of intent. We should treat this intent with all seriousness, and closely follow their progress, much as with Japan. Korea has, after all, demonstrated both industrial prowess (e.g. shipbuilding) and technological excellence (e.g. flat panel displays) in areas of great interest to us. They are investing heavily relative to their GDP and budget, and in an absolute sense in many of their priority areas; and they do have advantages in the region, such as a system that should make S&T integration across sectors relatively easy compared to, say, Japan, even if they have not invested as much for as long in scientific facilities and infrastructure.

With my JUSMAG-K hosts, CDR Jim Jepson and his new boss Col (Sel) Paul McQuinn, and the help of the Embassy, we were able to identify a number of institutes and facilities ONR should learn more about. As one example, two GRIs noted for their expertise are the Korea Institute of Science and Technology (KIST), and the Electronic and Telecommunications Research Institute (ETRI). I'm not aware that we've visited either. ADD's Technology Center is working in areas of interest to ONR, and we have not seen its work. ADD's university based Research Centers, especially the acoustics and automated control Centers at SNU, should be of significant interest, since they combine military and civil capabilities. There are several planning and policy groups, e.g. KISTEP, KOSEF, and the MND RMA group, that we should talk to. We would like better access to industrial R&D, particularly in the areas that MOST is emphasizing. And, I was told that it will be important to follow up in a month or so on my visit to MND to reemphasize our interest and develop better understanding of their priorities and interests in working with ONR as we access their academic and industrial research (again, it's important to note that they are used to DEAs and formal Cooperative R&D Agreements, and much less attuned to ONR's normal mode of working directly with investigators; I believe it would be to our mutual security advantage if we could identify projects where both defense sides have interests, yet the performers are in universities, industry, or civil GRIs). The MND visit should, I believe, follow an attempt to gain access to at least some of the Institutes and centers mentioned above.

As in many countries, personal relationships are very important in gaining access and cooperation. Language skill is also important, since although many Korean researchers have studied in the US and understand English well, they are not all equally comfortable speaking. And, given current sensitivities, especially in the mil-mil arena, working from Tokyo is not the most effective way to access Korean S&T, or to build interest in multilateralism (such as we had in ASIAEX, which I have frequently cited here as an example of a successful, open, mutually beneficial program; and incidentally, Jeff Simmen is highly thought of by those who know of ONR acoustics) in support of CINC engagement objectives.

I therefore recommend a two step approach to enhancing our collaborative opportunities in Korea. First, we should visit the institutes I have suggested, and perhaps others, using the good offices of the DCA component of JUSMAG to help with ADD, and the Embassy (or direct contact) for the Universities and MOST and Research Council institutes. This may take a couple tries, but I believe it would be well worth the effort. Then, armed with more specifics, we should revisit MND. Associated with this effort, we should continue to improve our understanding of Korean S&T policy and structure, by visits to, e.g., KISTEP and again to MOST, to NSTC and the Research Councils. This is probably best done with the support of, or even better in conjunction with, US Embassy EST personnel. We should also follow Korean developments more closely from the ONR Asia office, via available documentation and daily translations of key Korean articles (available from JUSMAG or the Embassy). We can also, with the assistance of JUSMAG-K, augment the "Who's Who…" brochure with information about MND/ADD S&T personnel and Centers. This would be of use to the US Country Team as well as ourselves.

Second, we should consider hiring a retired senior, experienced Korean researcher or S&T manager to help us understand their system, identify highlights, and gain better access for POs and other IFO staff when it appears there is an opportunity for collaboration. Dr. Shim, currently Director of the Chinhae ADD Naval Systems Center, is an example of the sort of highly knowledgeable and respected Korean scientist who could be very helpful to both of our nations in such a position.

In summary, although the Koreans themselves talk about S&T gaps between themselves, us, and Japan, and worry about China, they are dead serious about narrowing the gaps in many, and reversing them in selected, areas. And, if the newspaper articles are to be believed, their strategy is taking effect. Korea warrants the effort and relatively small cost it will take to improve our access and opportunities for mutually beneficial collaboration.

B.1. Philippines: Observations

The contrast between Korea and the Philippines is stark. Frequent (and often violent) government changes, a dismal tax base (only 6% pay income taxes) and structurally weak public finances (about 13% tax to GDP ratio, and about 70% of federal expenditures in 'non-discretionary" items), repeated skimming of much of the limited federal income by the leadership, weighty (and often corrupt or inept) bureaucracy, internal security problems, and a counterproductive set of laws have prevented the type of infrastructure investment that Korea has made, and that the Philippines will need to take advantage of its resources. There are many long term policy challenges, e.g. "agriculture absorbs 40% of the employed but accounts for barely a fifth of Philippine GDP…unemployment and underemployment are far more severe in rural than in urban areas"[8], albeit the general populace of Manila itself is poorly housed with inadequate

[8] U.S. Embassy's "Philippine Economic Outlook", June 2001

water and sanitation, and that doesn't even count the shanty towns. And although GDP is growing (projected at 2.7-3.2% for 2001), so is the population (alarmingly, at 2.32%/year for 1995-2000, given the extent of poverty and the demand for new infrastructure).

To quote from the Dept of Science and Technology's (DOST's) July newsletter, "The Philippines has been yearning for years to get out of the hollow of noncompetitiveness. Although it is rich in resources, it lacks in infrastructure and policy initiatives that could have perpetrated itself to the path of S&T development and competitive economic advantage. Moreover, the lack of a strong and national push for science consciousness and way of life have relegated the country to be a laggard as compared to many struggling counterparts in the Asian region. These have brought the Philippines competitive standing plummet through the years (sic)"[9].

On the other hand, the nation does indeed have some significant advantages. In contrast with Korea and Japan, the Philippines provides ample opportunities for women, at least in S&T. Females are numerically on a par or in the majority in universities, and occupy leadership positions in academia and the government (not the military; I didn't visit any businesses)[10]; the majority of my contacts were women. President Gloria Macapagal-Arroyo (referred to as GMA) seems to be widely popular, is clearly a dynamic leader with an agenda for national restructuring, elimination of poverty, and growth, and is eligible for election in 2004 (Philippines has a 6-year, one term Presidency). The vast majority of the educated public speaks English. Historically, the Philippines have provided people-talent to the world in fields as diverse as seafaring and medicine; and countries like Japan, facing labor shortages, are eyeing them for talent in fields such as IT. There are many excellent Filipino scientists, often with western educations, albeit they generally lack adequate research facilities. There is keen competition for slots at the best universities; and the country is becoming a leading regional center for e-services and IT-enabled business practices. There are indeed abundant human as well as natural resources in the nation, and the number of vehicles on the road (there is an interesting transition underway in Manila, from the traditional open Jeepneys to air conditioned 'Mega-Taxis"), and the many large modern buildings and huge shopping malls in Manila are ample evidence of significant wealth, even if it is unevenly distributed.

Although there is not an official S&T plan at the moment, DOST is in the process of developing one, following the priorities of GMA. These include resource development, agricultural modernization (and support of biotech - GMA was initially opposed but has been persuaded by the scientific community that it should be pursued with appropriate safeguards), support for information and communications technology (ICT), expansion of SMEs, and addressing concerns about the environment, safety and health, and disaster (especially tropical cyclone and volcano) preparedness. At issue are the nation's ability to generate and effectively and distribute the needed resources, not to mention prioritization beyond S&T for resources; there are so many needs -- from internal security, to transportation to take advantage of agricultural productivity, to basic infrastructure like schools and hospitals needed for the rapidly expanding population, to remedying the regional disparities, etc .-- that the challenges are immense, indeed more than one can expect the public sector alone to overcome, even discounting past performance.

None of this is to say that ONR (or DOS) should be uninterested in EST opportunities in the Philippines. Certainly there is a need for capacity building; but there are many excellent

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[9] "S&T: A key to economic development", Dr Paciente Cordero, Jr, NRCP Executive Director, in the 'Viewpoint' article of DOST's *S&T Post*, July 2001, Vov XIX, No 7

[10] I asked why this was so in several meetings. The general answer is that S&T is low paying, and women don't feel responsible for financially supporting the family so are free to pursue education and teaching.

scientists, niches of expertise, and exceptional bio- and geo-diversity in areas of significant interest, e.g. regional ocean conditions (I recall the importance of IW's in the Sulu Sea in the 80's) and tropical medicine (many of my senior academic contacts remembered the Philippine NMRU and expressed strong interest in reestablishing one), as well as common interests in maritime operations and ITC. If GMA can provide stability and integrity, enhanced industrial and ICT investment is very likely; and this will be accompanied by local R&D to take advantage of the intellectual resources. There is great potential if some of the structural deficiencies can be overcome, and it will be well worthwhile to watch the shaping of the S&T mid and long range plans, as well as the progress of the independent efforts of some of the academic leaders to enhance the research capacity of their institutions (more below). There are also a number of GRIs, none of which I visited, as well as many university-based institutes and centers throughout the country that would be worth a visit.

B.2. Philippines: Visits

MAAP: I had met the President of the Maritime Academy of Asia and the Philippines, VADM Eduardo Ma R Santos (AFP, Ret; previously, their DNI, then CNO), at the PACON 2001 conference. He hosted a morning visit (via helicopter to the Academy campus in Bataan) by my JUSMAG host CDR Bruce Kahl and myself. MAAP is an extremely impressive Academy[11], and if it is at all representative of what the Philippines can accomplish when there are adequate resources and competent dedicated management, then the country will indeed prosper. MAAP was privately capitalized and developed by the Associated Marine Officers and Seaman's Union of the Philippines. Modern classroom equipment has been donated, and the students are supported ($10K for the 4 year education), by a number of international shipping companies and maritime associations (students are required to work for their sponsor for 5 years).

The Philippines have historically provided a large percentage of the world's mariners, and some hundred schools have offered maritime training. However without adequate facilities, they have been increasingly been unable to meet IMO standards, so half of them have stopped their programs. MAAP is intended to return the Philippines to the peak of world class maritime proficiency. It has 150 students per class, equally divided between deck and engineering (an extremely rigorous curriculum, to meet a combination of national and IMO requirements); there are currently three classes - the first will graduate in 2003, and the new plebes had just arrived as we were visiting. The school stresses military discipline (graduates receive a reserve Navy commission), character, and leadership as well as academics, technical expertise, and seamanship; located in a relatively remote part of Bataan, there is little to divert the attention of the Midshipmen except sports and extension services (teaching English in local villages, and cleaning up the seaside).

The shore facilities are located in a converted hotel overlooking Corregidor, and are nothing short of exceptional; the training ship was at sea when we visited (there is also an operational deck house and engine room in a ship mock-up at the Academy), but I'd expect it is likewise excellent. In addition to educating Midshipmen, MAAP offers skill-upgrade training for professional seafarers, and when the facilities are complete this will include anti-piracy training. Although MAAP's mission is education and training, not research, I would commend it for a visit to anyone interested in maritime affairs, and I cited it as a positive example to all the Philippine public sector organizations I visited.

[11] As a former Trustee of Mass Maritime Academy and Director of a shipping company I am familiar with the type of facilities and training required for a first rate merchant marine education, and needed to meet increasingly stringent IMO requirements. My positive impressions were reinforced by Bill Eglinton, Director of Training at the Seafarer's Harry Lundeberg School of Seamanship in Piney Point, MD, who has watched the development of MAAP since its inception.

UP: We visited with the President of the University of the Philippines, Diliman, Quezon City, and the Directors of two of the Institutes[12]. UP overall has some 52K students; Diliman is the largest campus with about 30K, 20% of whom are graduate students. It is one of the top three public Universities, with a focus on S&T (70% of the student body; including medical, agriculture, fisheries, etc); the others are UP Los Baños (agriculture) and UP Manila (health sciences). Entrance is via the University's exam system and is extremely competitive, albeit the student body has a good diversity of wealth and regional origin. Pres. Nemenzo noted that 78% of the budget comes directly from the government (Dept Ed'n; the Universities were given fiscal autonomy under Marcos), with most research support from other Departments (e.g. DOST) or industry. Faculty salaries are very low, and the Universities have been 'left behind' in S&T due to a lack of investment in facilities (this became apparent in our later visits). Their biggest resources are lots of empty land (a rarity in Manila), and the brains of their students and faculty. He is therefore trying to attract industry to establish research facilities on campus, which will simultaneously provide access to talent for the companies, and modern equipment and tools for the UPD researchers. In addition, in partnership with a Japanese firm they are proposing to establish an IT training center on campus, and are applying for funding from Japanese Overseas Development Assistance (recall the anticipated Japanese labor shortage). They also have partnerships with Universities in Singapore, Australia, and southern Taiwan. Philippine laws restrict the amount of research funding that faculty can get from the government, and there are very cumbersome bureaucratic reporting requirements associated even with those small funds. Therefore, most of the non-education money is channeled through a number of 'University-affiliated Foundations' (officers are members of the Board of Regents) which get around these restrictions. There have been other legal and regulatory difficulties; e.g. for a long time they were unable to hire non-Philippine citizens (including Filipinos with, say, US citizenship). They are just beginning to set up an IPR office, under the VP for Development.

We next visited the National Institute of Molecular Biology and Biotechnology (NIMBB), under Prof. Virginia Monje. They have about 140 undergraduates, 40 MS and 20 PhD students, with 10 faculty. Faculty is permitted up to 50% research (12 of 24 units). Prof Monje reiterated the President's comments about low salaries (permitting other Universities to attract away their people) and little investment in facilities. We toured their building which had been converted from a fisheries lab, and indeed it was sparsely equipped, albeit with the basics for their work, including a small DNA sequencer. Their principal research program is on therapeutics for breast cancer; they have collaborators both in the Philippines and at Sheffield University, and are assisted by Dr Ed Padlan, recently retired from NIH. They are also working on DNA vaccines for Dengue and Hog Cholera, and have a number of research programs in molecular biology and genetics. The staff and their students are enthusiastic, and from what we could see make very good use of limited resources.

The Marine Science Institute, designated a "National Center of Excellence" (and spoken of with pride by the Government agencies) has about 45 MS and 22 PhD students and about 20 PhD faculty in physical, biological, and chemical oceanography, plus an additional 150 junior researchers and staff. In addition to the UPD facility (10 years old and not yet complete) they operate the Boliano Marine lab some 250 Km north of Manila. MSI scientists, most of whom have their PhDs from US, UK or Australian Universities, do a combination of basic and applied research focused on local seas. In addition to MSI's faculty, UPD has 4 marine geologists in the Geology Department, and a Seaweed Research Institute. MSI was founded by Dr Ed Gomez (PhD from SIO), a Philippine Academician who specializes in Tridacna; he was their Director for

[12] Our outstanding agenda with universities and government offices was arranged by Ms Terette Calabria, the FSN in the Embassy's EST section (under economics).

25 years. The new Director, who was selected as an Outstanding Young Scientist in 1994, is Dr Gil Jacinto, an inorganic chemist (PhD Liverpool) working on nutrients. MSI does not have its own ships, but does have access to those of the Department of Environment and Natural Resources' Bureau of Fisheries and Aquatic Resources, the National Mapping Agency, and DOD's OLAG (see below). Like the others at UP they get most (80%) of their research funding through grants (DOST, UN, etc), have their own Foundation, and are under-resourced (e.g. they have only one ADCP, and a Chelsea Instrument's AquaShuttle but lack the training to use it except as a CTD), and would benefit from enhanced collaboration. They also suffer from some legal restrictions, e.g. on 'bioprospecting', which (in spite of major problems with exploitative fishing) is read to prevent collecting for academic research or coral regeneration.

Historically, much of MSI's research has been in the western or interior seas (e.g., Sulu Sea); they are now starting to work on the Pacific side, with interest in the Mindanao current and its bifurcation, and possible upwelling. They have some interesting programs in the South China Sea, notably a bilateral effort with Vietnam that has made a couple transects between the two countries; and an UNCLOS-based multilateral effort called Managing Potential Conflicts in the South China Seas, under which marine scientific research seems to be an acceptable engagement mechanism. This program has been 'brokered' by Hashim Djalal of Indonesia, and there has apparently been some Canadian sponsorship of the marine sciences and biodiversity technical working groups (see the web site of Ian Thompson-Gault at UBC). This project may offer some opportunities for multi-lateral research in the area, albeit Dr Jacintos noted that the Chinese in particular prefer bi-lateral efforts, especially in the SCS, although they are participating in a multinational cruise this year since it is in Indonesian waters. Under UNDP, MSI is trying to expand the construct of Marine Protected Areas to some of the SCS islands as a means of cooperation, since they appear to be breeding grounds that provide larvae that end up in Philippine, Chinese, Taiwanese etc waters[13]. In general, MSI would seem to provide a good basis for ocean based science and engagement programs in Philippine and neighboring waters.

UST: The "University of Santo Tomas, the Royal, Pontifical and Catholic University of the Philippines, (is) a Dominican institution of learning" (quote from its brochure) founded in 1611 and looking forward eagerly to its 400th Anniversary. We were hosted by the Dean of the College of Science, Biochemistry Prof. Gloria de Castro-Bernas. UST is one of the four leading private Universities; it has some 32K students, from kindergarten through MD, JD, and PhD (between their hospital and Church, she characterized it as truly a womb to tomb operation). UST's original courses were in law, medicine, and pharmacology, and it retains these strengths, especially in medicine and associated sciences such as nursing. Today there are 8 UST Faculties, 7 Colleges and a Graduate School (Colleges [and some Faculties] offer only undergraduate degrees, although some disciplines, e.g. chemistry, are gaining enough strength to become 'vertically articulated'). There is also an Office of R&D which handles all research administration, and under which the College and Faculty professors do their research (as in UP, they can get support for up to 50% of their time for research). It has five research centers (Natural Sciences, Social Sciences, Education, Health Science, and Intercultural), as well as a Grants Office which is the implementing arm of their Foundation (same scheme as at UP…). Like UP, UST has its own set of tests and interviews for admission, and claims diversity of class and locale in the student body. Tuition varies with subject, and is 18-20000 Pesos/semester for science. The College of Science has the highest percentage of faculty with advanced degrees, and some 2700 students. It offers all the normal science courses, but specializes in biomedicine and natural products. Dean Bernas noted that many students these days are lured into IT, and it is a

[13] Such efforts are of course complicated by territorial disputes, not the least of which is the fact that the Philippine Constitution recognized the maritime borders of the 1898 Treaty of Paris, which are not in accord with UNCLOS.

task to motivate them back into the basics, especially math and physics. In preparation for the Anniversary they are starting a degree program in Applied Physics focused on instrumentation (we reviewed the curriculum), and expanding their biology program to offer environmental as well as human oriented biology degrees; new curricula must be approved both by the University and the national Commission on Higher Education, and are complicated by preparatory math, Philippine national, and religious classes. We did not get much information about UST research, but apparently there is some work on biomedical and environmental chemical sensors.

DOST: The Department of Science and Technology has a total of about 5000 employees, of which some 1500 are in the seven government research institutes (Industrial technology, Nuclear Research, Advanced S&T, Forest products, Food and Nutrition, Metals Industry, and Textiles). There are also seven S&T "Service Groups" (Science Education, S&T Information, the Philippine Atmospheric, Geophysical and Astronomical Services Administration [PAGASA, the Weather Bureau], Vulcanology and Seismology, Technical Applications and Promotion, a National Computer Center, and a Science High School). PAGASA was recently moved to DOST from DOD…as a way, we were told not completely facetiously, of reducing the Defense Budget and increasing the S&T budget. DOST, as noted above, is following the priorities set by GMA: agriculture and ICT are the primary disciplinary beneficiaries. DOST has an overall S&T Coordinating Council that oversees programs of its various sectors and other government Departments, an IT Council that advises the President and others on IT policy and coordinates IT plans and programs, and five sectorial Councils that are responsible for DOST's planning and programs in Advanced S&T, Agriculture, Forestry and Natural Resources, Aquatic and Marine R&D, Health, and Industry and Energy. A hand-out entitled "Things you may be interested to know…" talks about R&D successes in agriculture, medicinal plants and cone-shell derived products (from MSI), waste management, red tide detection, and the breast cancer drug program at NIMBB. DOST also has programs to enhance technology transfer to Philippine SMEs, and major efforts for 'human resource development' (its 2nd S&T Education Plan [STEP] covers 2001-5, and includes extensive legislative, QA, advocacy, research, and assessment agendas, as well as teacher and faculty development programs; while I can not comment on implementation, this program seems well planned and of sufficiently long duration to demonstrate a serious national commitment to S&T education).

NAST: The National Academy of S&T, established in 1976, is one of two advisory organizations under DOST[14]. Created to honor Philippine "Academicians" (originally a maximum of 50, now 75) and "National Scientists" (eight), it was later charged with acting as an advisory body to the President and Cabinet. It also has international linkages; e.g., to the AAAS in the US. NAST has five discipline-oriented divisions, and soon will split off Engineering. Its members are recommended by Departments or other national units, and elected by majority vote of the members. Academicians are expected to serve on advisory panels and committees, and are accorded privileges (e.g., medical care, and state funerals for National Scientists). NAST recently celebrated its 25th Anniversary. Its members apparently played a significant role in gaining GMA's support for biotechnology. It is developing an S&T outreach museum next to its offices.

OLAG: The Navy's 3-year old Ocean and Littoral Affairs Group reports to the DNI. It has about 14 officers and 80 enlisted, and in its current stage of development focuses on hydrography. Many Naval officers are very interested in the oceans, and this offers them an opportunity for a subspecialty that provides important information to the Navy, complementing the activities of the national mapping agency. OLAG receives considerable support from

[14] The second is the National Research Council, which provides grants in aid support for basic research

NAVOCEANO, so I presume that their capabilities and interests are well known to Navy. A couple of additional notes on the Philippine Navy are that there is a single AFP academy; graduates progress through their careers in parallel competition, and the retirement age is 56 (or 30 years of service). There are few specialties; essentially one 'operational' specialty in Navy, so that intelligence, METOC, SPECWAR etc are subspecialties. There is considerable pressure to fulfill a rigorous set of operational positions for promotion, so tours lengths are quite short, normally only one to two years. I believe this is disruptive. Most naval vessels are quite old; the new equipment they are acquiring, largely with US assistance, largely comprises 78 foot patrol boats, which they operate as commissioned units. During the period of US occupation of Philippine bases they relied heavily upon us for 'blue water' operations and capital equipment; their major focus has been counter insurgency, and even that capability has considerable deficiencies. There is essentially no S&T program within the DOD, at least as far as I could discern.

B.3. Philippines: Comments and Suggestions

It should be no surprise that a developing country such as the Philippines, particularly one that has been under the 'shield' of foreign powers until recently, has a somewhat less than robust S&T program. As important as S&T may be for development and economic strength, and they recognize this, there are simply too many other structural issues, including internal security, to permit the sort of major investment required to develop world class status in most fields. On the other hand, as I have tried to point out, there is a tradition of excellence in health sciences and maritime operations, a strong thirst for education, many excellent universities both public and private, and recognition that there are two sectors -- ITC and agriculture -- that will in the near term be critical for the economy. Perhaps most importantly, the Philippines' human resources are likely to prove attractive to neighbors looking to expand their access to well trained labor.

In spite of the generally low level of S&T facilities, the Philippines are likely to harbor some gems that it would behoove us to discover. These could be both people, and projects. Of equal importance is access to their geographic and biological diversity, and the potential for Philippine leadership in multinational ocean research in the SCS and SW Pacific.

I recommend at a minimum the following steps:
- support the EST officer, and in particular the EST FSN Ms Calabria, in expanded efforts to visit and report on researchers and their programs in universities and the DOST Research Centers. Ms Calabria has already undertaken to develop a 'Who's Who' like the one we were provided in Korea, and given the type of appointments she was able to arrange for me, she should be able to do an excellent job of identifying key people and projects. IFO can then follow-up as appropriate.
- Develop an improved understanding of the Philippine-VN and proposed multilateral projects in the SCS. Someone at DOS or ONR may already have an in depth appreciation for these programs, but given the CINC's emphasis on enhanced regional engagement we should ensure we thoroughly evaluate the possibilities[15]. This should be an IFO action.

[15] We were told that GMA was not particularly supportive of CINCPAC's emphasis on multilateralism ("she nodded"). Not surprising given the region's history. Nonetheless MSI scientists are inherently regionally and globally oriented, and probably would welcome an expanded regional seas program. And, my own two experiences in regional multilateral ocean science - POEM and CoMSBlack - were both formed among scientists from hostile nations. I think this one is worth pursuing, unless it has already been wrung dry.

- Follow the development of an S&T plan along the lines of GMA's priorities, and monitor financial and program development actions. Again, we should be able to rely upon Ms Calabria, particularly if ONR can provide her a modicum of support.
- As with all other countries in the region, enhance the IFO's access to locally developed information, which can quite simply be accomplished by requesting through JUSMAG that the IFO be added to distribution lists of routine products, plus periodic emails and phone calls.
- Stay in contact with VADM Santos and his MAAP. This is probably most easily accomplished by ONR participation in PACON, where he is active. PACON can indeed be a very powerful forum for exploring research opportunities. We should not simply let NOAA be the only US participant. If we truly intend to support the CINC, an in-being multilateral ocean R&D group deserves priority attention (probably our best POC is Gary Jensen, located near PACON's Hq on Oahu). I also suggest we support MAAP's efforts to improve quality seafaring, if by no other means than occasional visits.
- Take lessons from the Philippines' S&T gender equality, and promote same.
- Consider the reestablishment of a NMRU in the Philippines. The Institute of Tropical Medicine is internationally reputed, NIMBB is working on DNA vaccines and other protocols of interest to DOD, many senior Philippine scientists and administrators remember the previous unit with respect and admiration, and the Philippines offer access to many epidemiologically interesting issues, as well as a well trained, English speaking corps of medical researchers and practitioners. Tropical medicine, like ocean science, is a powerful field for multilateralism; and this is one US re-introduction that would be welcomed with open arms, from what I have heard.

C.1. Hong Kong: Observations

The Consulate Team emphasized that the "1 country, 2 systems" status of Hong Kong since its reversion to mainland control as a Special Administrative Region (SAR), is working. Hong Kong today has strict export controls, a notably free press, and as least as much democracy and respect for human rights as it had under British administration. Business and educational ties with the mainland are increasing rapidly, but the same can be said for almost any entrepreneurial country, especially in this region; and there is indeed a good bit of competition with businesses across the border as Hong Kong strives to build its R&D base and gain competitive advantages as a 'knowledge community'. PRC does of course control the formal aspects of diplomacy and foreign policy, and exercises its responsibility for security through a (almost invisible) joint military garrison (headed by at Lt. General). But for all practical purposes, and in the eyes of both the locals and the Consulate, we can and should treat Hong Kong an 'independent' entity.

Hong Kong shares with Seoul a super infrastructure, a clean, neat, bustling façade and population, and improved if still bad traffic and air pollution (and male predominance, although not exclusivity, in senior academic circles). With Manila, it shares English bilinguality and a structurally deficient tax base. The maximum income tax is 15% and few pay it; government funds are derived almost solely from land sales; and in downtown Hong Kong itself, this means land fill (there is considerably more of Hong Kong since I was here in 1962). One of the surprises for a visitor is that once out of the city proper and past the bustle of Kowloon, the SAR is rural; some 60%+ of the territory is hilly forest and reservoir, and the total population is still less than 8M, compared to Seoul's 22M urban sprawl (and like in Seoul, they live vertically, even in the 'new towns'; and they prefer the city, for the sake of children's education).

Although by and large the streets are neat and the air tolerable (barely), the waters are sewage and trash pits. The British did little or nothing to abate pollution, the SAR administration is just starting to take notice, and the Pearl River dumps immense amounts of waste and sediment to the

NW. And on the financial side, albeit business is what makes the place what it is, the government's approach to obtaining revenue is inadequate, particularly after the financial crisis and property value crash (although there is still lots of construction), and we were told several times that a sales tax or VAT will almost inevitably be needed. So, there is a budget deficit, and a structural revenue squeeze. Such issues matter greatly to the government-funded educational and university-based research system; even now, although funds are characterized as 'adequate', they are cutting back (e.g., the flagship Hong Kong University of Science and Technology, HKUST, had a 10% cut in the last 3-year budget period, and an additional 5% cut in the current one), and there is an insufficient culture of (or tax incentive for) philanthropy to make up the difference[16].

Like many of its neighbors in the region, Hong Kong has some hard choices if it wants its future to be as bright as its past. The immediate threat of a Communist 'takeover' is now past, so many of pre-97 ex-pats are returning. The modern and efficient container port is #1 in the region; and the city remains very much a business and financial hub. None of these advantages however is unchallenged. There is no freight rail to the mainland, and roads are inadequate to serve China's burgeoning needs; as China moves to open its west, they are upgrading and constructing other ports, and while Hong Kong will never be abandoned, it may well lose its primacy. Almost all of Hong Kong's industry has moved across the border; what's left for the city is ownership, transshipment, and services[17]. The ethos and educational drive in the SAR and mainland differ significantly, in spite of HK's efforts to develop its S&T over the last decade to replace the drain that preceded the turnover. Most HK students go into business directly after graduation (3 years of University under a British-like system); even at HKUST, only about 15% go directly to postgraduate studies. HK therefore imports higher level engineers and technicians; the satellite operations company we visited (APT, see below), admittedly half mainland-owned, gets all its technical staff from PRC, and our hosts noted that HK has little interest in satellite related technologies. And thus while HK is touting itself as the 'knowledge society' and a base for global e-commerce, it is by no means alone, or even ahead in my opinion, in the IT game.

Hong Kong has for some time recognized these deficiencies, and prompted at least in part by emigration in the mid to late 80's, started to take steps to enlarge its educational and S&T base. Notable among its innovative moves were the greenfield creation of HKUST and the conversion of some of the colleges and polytechnics to University status. There are now 8 government supported Universities, which provide tertiary education for 18% of high school graduates (a government-set figure; they believe this is the percentage that will profit from a formal baccalaureate education[18]); another 12% receive post-secondary technical or community college education, and they intend to double the total to 60% (although the government will just offer incentives rather than directly fund the growth or the tuition of the additional 30%). Of the 8,

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[16] One of the biggest donors is the Jockey Club. It paid for fully half of the construction and equipage costs of HKUST, plus HK $130M for its Biotechnology Research Institute, as well as being the mainstay for many cultural and social programs throughout the territory. Huzzah for horseracing.

[17] We were commended to read *Made By Hong Kong*, a companion piece from the MIT scholars S. Berger and R. Lester who wrote *Made In America*

[18] Students take an entrance exam, and select their preferences; they are then sorted by computer and assigned to a University and course. HK not only controls the number of its own students, but also limits international input, to 2% of total (mostly mainlanders); an additional 2% who pay their own tuition are also permitted. However, we were told the actual figures are much smaller than 4%…closer to 1%. Things are very different for graduate education; HK 'imports' about 1/3 of its MS and PhD students (largely from the mainland), reflecting the 'get into business' bias of the local population. Neither the students nor the companies have historically, or even today, seen much need for education beyond a (poly-like) baccalaureate.

three are considered the primary Research Universities: the now 10-year old HKUST, and the older Chinese University of Hong Kong (CUHK, so named because it is tri-lingual) and Hong Kong University (HKU). A close runner-up and pushing hard is Hong Kong Polytechnic University (PU), which competes somewhat less well for research grants, but uses most of its sizable Research Grants Council direct allocation for R&D (it is considered to have special expertise in areas such as textiles and design).

University operations and tuition are funded by the government through the University Grants Committee; there is an assessment system by which student allocation and distribution are based, thus also funding. The University is free then to apply these block grant funds as it chooses, albeit its choices and associated performance are then reflected in future year allocations. Total annual education (and associated research) funding is about US $1.2B. Under the UGC is the Research Grants Council (RGC), with an annual budget of about US $60M (which goes about 3x as far as it would in the US since it doesn't have to cover salaries or overhead[19]). Most of this goes to its competitive grant program; e.g., in 1999, of a total of HK $423.3M, $324.5M supported 578 projects (of 1496 proposals) selected by a peer review process. RGC also allocates part of its total in blocks to the Universities for them to fund small scale projects, field trips, and travel; reserves some for student projects, and a modest amount for research base support (infrastructure) and to promote collaboration among institutions; a very small amount for co-funded programs with Germany and France; and HK $10M for a joint (2:1) funded program with their PRC counterpart. Although project selection is openly competitive (the Council comprises distinguished international as well as HK academics, and there are four prestigious, predominantly locally-manned, panels for proposal review -- actually creating 'superior' rather than 'peer' review, which I personally much prefer), the overall allocation ('99) was engineering 37%, physical sciences 14%, biology and medicine 30%, and humanities, social sciences and business 19%. While RGC is basically quality-oriented, in 1999 for the first time it developed a report to the Secretary of Education on needs and priorities of research in the universities (nfi); and conversations with scientists indicate that there seems to be a bias toward applied research (albeit soundly founded on basic work) that will be of benefit to the community, and information related sciences (part of this reflects the interest of students - e.g., the PU EE Department changed its name to Electronic and Information Engineering, and immediately got higher caliber students).

To date, almost all research has been done in the Universities. And, given the newness of HKUST and the conversion of the colleges/poly's, their experience (and thus the IPR) is limited. When they decided to move however they did so with a vengeance, as the caliber of the international faculty of HKUST (and some of the others) and its rapid rise to excellence in several areas (e.g., top business school in Asia) demonstrates. And, the burst of investment during the boom years has provided superb lab facilities across the University system. The two we visited (HKUST and PU), and I'd suspect most others, have programs to attract industry and spin off IPR and new companies. The government however understands this is not likely to be enough, and therefore has initiated a number of programs to encourage industrial-academic interaction. An Innovation and Technology fund provides matching grants with industry, and a Teaching Company scheme shares costs of a research-oriented (only 9 credit hours of class over two years) 'Masters of Philosophy' program. The government also is constructing a new Applied Research and Technology Institute (ARTI), and associated high-tech park, near CUHK. Given the cost of land and construction in Hong Kong, such inducements can be very effective (e.g., the Industrial Estate at Tai Po, where we visited APT, was jam packed). And, a few years ago the government

[19] Much of this information came from dinner conversation with Ken Young, who has been on the UGC for 7 years and took on the RGC Chairmanship in 1999. Some of the statistics are from the RGC 1999 Annual Report, dated Oct 2000

committed to Cyberpark, a strategic cluster of facilities (offices, apartments, shopping, etc) for about 250 local and multinational companies along a strip of HK's waterfront. However Cyberpark is controversial -- there are accusations of favoritism to the developer who is footing the bill for the whole thing (except for the free government land), expecting to recoup expenses from the sale of the apartments alone -- and is no longer as attractive as it was when conceived[20]. This is just one more indication, to my mind, that Hong Kong, for all its past advantages, will not find the transition into the 21st century an easy one; competition is stiff, the rules of the game have changed in many ways, and there are some structural and attitudinal problems that will be tough to overcome.

C.2. Hong Kong Visits

PU: Hong Kong Polytechnic University, located near the Kowloon side entrance to the central tunnel to HK city, was formed as HK Polytechnic in 1972 and converted to University status in 1994 as part of the move to increase availability of tertiary education. It retains elements of its practical roots in seeking to produce the "preferred graduate" in marketplace focused skills, and be of "practical value to employers". It is now the largest of the 8 HK Universities with about 1K teaching staff and 12K full time, 6K part time students in 26 Departments and 3 Centres under 6 Faculties (Applied Science and Textiles, Business and Information Systems, Communication, Construction and Land Use, Engineering, and Health and Social Sciences). In addition to traditional courses, PU offers degrees or diplomas in such areas as fashion and textiles, design, real estate, international shipping and transportation logistics, and occupational health.

The 1999/2000 annual report lists new research centers in China Accounting and Finance, Construction and Real Estate Economics, Structural Engineering, Advanced Manufacturing Technology, Fire Engineering, Urban Environmental Technology and Management, and Geo-Information S&T. It also notes that PU is the leader in the UGC's "Areas of Excellence" program in "Chirotechnology for Chiral Drugs", and co-investigator for "Chinese Medicine" and "Wireless Communications". Its own "Areas of Strategic Development" are Chirotechnology, Building Technology for Dense Urban Areas, Multimedia Signal Processing, Product and Process Design ("a new learning factory"), myopia among Chinese people, smart materials, apparel products development and marketing, and the merger of Chinese therapeutics and western rehabilitation.

After an introductory video we met first with Prof Choy, who is Dean of the Faculty of Applied Science and Textiles, Head of the Department of Applied Physics, and Head of the Materials Research Centre. His own research started in polymers, then expanded into ceramics and composites. He helped us understand the University system and its evolution, and trends in HK education. He expressed concern that students have little interest in basic science courses, and are excessively attracted to IT, especially software that is related, perhaps inevitably for HK, to business and banking. The government is pushing too much, in this direction, to the detriment of hard engineering and innovation; the University likewise follows this trend in its own decisions about allocations. Prof Choy has started a program in Engineering Physics (allocated 37 students per year) to help attract students. The Department as a whole, with 19 staff, 20+ graduate students and 30 research associates, is oriented toward manufacturing automation, including sensors and actuators. On the positive side, salaries are good, the Universities have excellent new instrumentation, the teaching load is not all that heavy and faculty have adequate resources and opportunities for research.

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[20] A 17-19 Aug Asian Wall Street Journal article quotes an analyst as saying, "two years ago, companies would have been more enthusiastic about the project, when Hong Kong was still a stepping stone to China…now they'll think twice before taking any decision."

We next visited with several young and enthusiastic faculty in the Department of Electronic and Information Engineering (EIE). Two of them, Dr Surya who is researching GaN thin films, and Dr Wai who is working on optical transmission, commented that they had ONR support while getting their degrees in the US. Both maintain their contacts stateside, and also collaborate with faculty of other universities in HK. Dr Surya also works closely with researchers in Taiwan (esp the "White Light" project). EIE has over 500 full time and 150 part time undergraduates, 70 research and 250 coursework graduate students, making it one of the largest academic units in HK. As noted above, EIE improved the quality of its students when it added "Information" to its name. Our hosts emphasized their increasing interaction with industry, which they promote by industrial visits and Open Days, or showing their research at industrial fairs and trade shows. There is also a new university-wide Institute for Enterprise which "serves as a one-stop shop for companies seeking support for staff training, technology and product development." They compared their efforts to those of Japan, i.e. needing to get past copying or borrowing S&T, and developing an indigenous capacity. Opportunities for consultancies with industry are increasing, and offer the faculty ways other than papers to demonstrate the value and quality of their performance. We toured Dr Surya's molecular beam epitaxy and materials characterization labs, then saw several demonstrations (video conferencing, wireless control, video data storage, etc) in the Centre for Multimedia Signal Processing, one of the Areas of Strategic Development, which was set up by PU with a HK $30M allocation. EIE also has a power electronics research centre, a communications research group, and Dr Surya's thin film optoelectronics group. Overall, in spite of ranking behind HKUST, CUHK and HKU and about on a par with CityU in the RGC's competitive bid funding, PU ranked 3rd in overall research grants and contracts in 1998/99, and I was impressed by the enthusiasm and the quality of research of the scientists we met.

HKUST: In stark contrast to the dark brown brick and inner city location of PU, HKUST is white and shiny and sits on a lovely country hillside with a magnificent ocean view, well NE of the bustle of the city. Also, it has housing for most of its students and faculty. As noted above, it was conceived in the mid-80s, and was in full operation by 1991, with a renowned international staff. We didn't visit any teaching faculty, but after the introductory video spent an hour with Prof Tony Eastham (originally from Ontario), the Associate VP for R&D who also is President and CEO of the University's RanD Corporation. We also saw several groups of enthusiastic newly arriving freshmen. HKUST was originally planned for over 10K students, but due to funding constraints now has about 5500 undergraduate and 1750 postgraduate students. Its ~450 faculty all have doctoral degrees, and extensive research as well as teaching credentials. The facilities are nothing short of magnificent, as can be imagined for a grounds-up, purpose-designed and built premier S&T institution now only about 10 years old.

HKUST offers degree programs in Schools of Science (6 fields, 1500 students) , Engineering (16, 2900), Business and Management (12, 2600), and Humanities and Social Science (3, 132), as well as interdisciplinary MSc's in biotechnology, environmental engineering, environmental science, and materials science and engineering. Befitting its emphasis upon interdisciplinary research of "regional relevance", it has nine Research Institutes, 33 Research Centres, and Central Research Facilities that include an Advanced Engineering Materials Facility, a power wind and wave tunnel (for boundary layer studies, with an emphasis on structure interactions), a geotechnical centrifuge (for, e.g., slope stability), CAD and Manufacturing facilities, a materials characterization facility, and a microelectronics fabrication facility. Altogether, this is a rather idyllic spot for academic S&T. HKUST's research funding has grown rapidly; from about HK$40M in its 91-92, to $285M in 1999-00, of which ~$114M is from RGC, $32M from UGC, $89M from the HK SAR Government, $49M from private funds, and <$2M from non-HK sources.

Prof Eastham noted that although HKUST leads in the per-capita allocation of research funds, competition is fierce, and there are resource constraints, so that focusing is necessary. HKUST has therefore decided to concentrate on seven areas: bioscience (neuroscience, proteins, cancer, Chinese medicine and drugs -- using western technology to test efficacy [HK definitely sees itself as a bridge between E&W in the area of medical practice]), communications and information systems, environment, Chinese business and society, industrial and EE, infrastructure, and materials (nanomaterials, advanced engineering materials, solid state, and superconductivity, the specialty of the new President Prof Paul Ching-Wu Chu, from the University of Houston).

We also visited the Center for Coastal and Atmospheric Research, and were briefed on a number of their projects, e.g. wind shear warning for the airport, wind impact on the fast train from the airport to the city, pollution in the Pearl River Estuary, and the development of a coupled air-sea model of the region (using MM5, POM, and WAM). Neither the Director Dr Chen (a mechanical engineer from CalTech) nor Deputy Dir Dr Lau (mathematician from Princeton) were present, so while we gained a good appreciation for the scope of work I can't comment on their particular strengths and interests. The center would appear to form a good basis for research in the area, and they do intend to extend their modeling of the Pearl River Estuary into the SCS. Given their linkages to, e.g. NCAR, this could be interesting.

APT: Asia Pacific Telecom Satellite Company is located in an industrial estate in Tai Po, in the New Territories. Their site next to the bay and a waterside park gives them lowered construction costs and assurances of an unobstructed view for their antennas, within the SAR. APT is owned by a consortium of China Telecommunications Broadcast Satellite Corporation, China Aerospace S&T Corporation, CASIL Satellite Holding, Ltd, (all mainland companies) SingSat which is a subsidiary of Singapore Telecom, and Kwang Hua development and investment, from Taiwan. They currently operate three satellites: APSTAR I and IA are Hughes HS376 satellites, each with 24 C band transponders, positioned at 138º and 134º East, and APSTAR IIR, a Space Systems/Loral FS1300 satellite with 28 C and 16 Ku Band transponders located at 76.5º East (Loral is the principal customer for this satellite; they lease 43 of the 44 channels). Overall, coverage reaches from India through all of China to most of SE Asia. They have a contract for a new SS/L APSTAR V to replace APSTAR I (38C and 16Ku Band transponders), and an RFP for a similarly capable one as a backup or replacement for IA; coverage from these will extend to Hawaii, allowing them to offer US connections into Asia. They use Chinese "Long March" rockets for launch from Szechuan province. At issue are the export licenses for APSTAR V and VB. We were given a very thorough brief, and a tour of the entire facility, which was clean and efficient. Most of the equipment is of US manufacture. As noted above, their technical staff is largely from the mainland, and administrative and business staff from Hong Kong. Their principal competitor is AsiaSat, which has 50/50 European and Chinese ownership.

C.3. Hong Kong Comments and suggestions:

We were told that there is one person in the Economic Section of the Consulate that spends a third of his or her time on environment, and another that spends a third on S&T. I'd guess that such assignments neither permit much scope for digging, nor attract anyone with top scientific credentials. Given the economic importance of Hong Kong and the importance of S&T to the future of Hong Kong's economy, the SAR's ability (still) to serve as at least an intellectual middle-man with the mainland, and the fact that there are some 50K Americans here, I'd suggest that HK S&T warrants a bit more dedicated attention. Among the other benefits of stationing someone here at least for a while are the pleasant and relatively easy living conditions (English-speaking etc - my advertisements not needed), the excellent access to the new airport and to

neighboring countries (like the Philippines and Vietnam), and in particular the access to the mainland, and to mainland scholars who study in Hong Kong. On the other hand, research is predominantly done in the Universities, there are only 8 of them (and not all 8 are S&T oriented) and many of the best faculty have US or European postgraduate educations and thus colleagues; indeed, many of the HKUST faculty were recruited from North America within the past decade.

Certainly we should not ignore Hong Kong; at a very minimum it is strategically located, and its researchers can play a role in studies of the surrounding environment. More importantly, the evolution of RGC-generated priorities, the establishment of the ARTI, and the involvement of business and industry with R&D all should be followed closely, if indeed we are serious about improving our understanding of S&T strategies and competitive positions in the region. Hong Kong is a major player, and can not be ignored. And, as mentioned above, it's a good ops-base.

Any further recommendation on my part with regard to personnel tasking, other than that it would be very nice to have a 'Who's who…" like the one in Korea (which we could get rather cheaply, I'd imagine, through a contract with someone UGC could recommend), has to be caveated by the fact that I have not yet visited VN or Singapore, both strong candidates for either ONR or STA-associated EST augmentation. Further, at issue is how to access mainland S&T, once we get past the current restrictions. One thought in that regard was provided by Capt Kaplan, head of the Office of Liaison Administration, who recently arrived in Hong Kong from three years in USDAO Beijing. In the mid-90's, there was discussion (and a draft MOU) about a personnel exchange with the PRC's Navy Research Institute; the appropriate US counterpart could be some amalgam of CNA, NWDC, and ONR. All discussion stopped following the Belgrade Embassy episode in 99…but it may not be inappropriate to reconsider this possibility following President Bush's trip to APEC in Shanghai this fall. Augmentation of the 2-person Beijing EST staff with a scientist or engineer from some other USG agency or FFRDC may well be a very interesting step; as an alternate, perhaps such an individual could work from Hong Kong. I do strongly suggest that the history of prior discussions be reviewed at DOS, and that ONR consider what role it may wish to play if the opportunity to extend collaboration occurs. Certainly the success of ASIAEX gives us reason to wish to maintain the momentum.

Briefly, one other issue is how to collaborate with HK scientists in the near term. They are government salaried, and in general have adequate research resources. So, what can we provide to stimulate ONR-oriented projects? France and Germany have established dedicated cost-sharing S&T programs, but at the level of only about HK $1M/year. I can't imagine that any program of this size would benefit either them or us beyond 'goodwill', which is hardly required given the fact that so many of their researchers have degrees and colleagues in the US already. Rather, from my discussions, I'd suggest that the best approach is to use a mechanism like (but separate from) NICOP for shared graduate students, or even better PostDocs.

In fact, now that I think about it, and recollecting my European experiences, I would suggest that ONR consider adding one more new program (yes, I know that 'splitting the hairs' on funding means that those POs with adequate resources can blow it off…), oriented specifically to offering international PostDoc-sharing opportunities (Post-Docs from either partner, or both). We have many countries we collaborate with that either don't need, or can't accept our funding (HK is such, Singapore is another). Every researcher however would love to have an extra PostDoc (Saalfeld Scholar?). And while PostDocs often may not want to spend their entire period overseas (either direction of travel), a 'combined' multi-national appointment, particularly if it was designed to accommodate serious concerns such as family and expenses without terribly laborious administrative burdens, could be both prestigious and scientifically profitable. I'll

therefore take this opportunity to request that this proposal be discussed at this year's "All Hands" IFO meeting in London this September. It seems to me that something on the order of US $500K could start the effort, if we were selective with initial partners and made this a significant, internationally recognized award.

Itinerary (Doug Edsall, IFO Tokyo, has contact information):

Korea

4 August, Saturday: arrive Seoul @1730; Host CDR Jim Jepson, USN, JUSMAG-K
RON Dragon Hill Lodge, Yongsan Army Base

5 August, Sunday: Seoul: Insadong, temples, shrines

6 August, Monday: AM: Seoul National University, Naval Architecture and Marine Engineering Department, College of Engineering
PM: Ministry of Science and Technology

7 August, Tuesday. AM: Courtesy Call, CNFK COS; Embassy Team Brief
PM: DMZ tour

8 August, Wednesday: Agency for Defense Development, Naval Systems Development Center, Chinhae; Director Dr. Shim

9 August, Thursday: AM: Agency for Defense Development: Courtesy Calls Capt Shim, Deputy Cdr, NAVSEASYSCOM; RADM Kwon, Commander, Combat Development Command
PM: Agency for Defense Development, Vice-President Dr. Park; Korean Research Institute of Ships and Ocean Engineering (KRISO), DG Dr Lee

10 August, Friday: AM: USFK Threat brief; Courtesy Calls, JUSMAG-K Chief
PM: Ministry of National Defense: Director Research and Planning Division, Mr. Chang; DG Programs Management Bureau, MG Byung-Go Yu

11 August, Saturday: Transit to Philippines

Philippines

11 August, Saturday: Arrive Manila @1130, Host CDR Bruce Kahl, USNR, JUSMAG
RON The Peninsula, Makati

12 August, Sunday: Intremuros, Fort Santiago, Museum of the Pilipino People
Dinner: VADM Santos, CDR Kahl, Dr Edsall

13 August, Monday: AM: Maritime Academy of Asia and the Pacific, VADM Eduardo Ma R Santos, AFP (Ret)
PM: University of the Philippines, Diliman, Quezon City; President Francisco Nemenzo; Nat'l Inst of Molecular Biology and Biotechnology Prof. Virginia Monje; Marine Science Institute, Dr Gil Jacinto

14 August, Tuesday: AM: College of Science, Univ of Sto Tomas, Dear Gloria Bernas; Dept of Health, Undersecretary Margarita Galon
Lunch: Oceanic and Littoral Affairs Group
PM: National Academy of S&T, Pres. Dr Perla Santos-Ocampo; Dept S&T Secretary Estrella Alabastro

15 August, Wednesday: Transit to Hong Kong

Hong Kong

15 August, Wednesday: Arrive Hong Kong @1545, host LCDR Jack Shea; RON Grand Hyatt

16 August, Thursday: AM: Consulate Team brief
PM: Hong Kong Polytechnic University; Collaboration staff, Prof. Choy, Applied Physics; Prof. Tse, Assoc Profs Surya & Wai, Electronic & Information Engineering
Dinner: Dr Kenneth Young, Chairman, Research Grants Council, & Mr. Li, Dep. Sec.

17 August, Friday: AM: Hong Kong Univ of S&T; Assoc VP for R&D & Pres/CEO, RanD

Corp, Prof Tony Eastham; Center for Coastal and Atmospheric Research
PM: AST Satellite Control Center
18 August, Saturday: Peak; Aberdeen; Central
Dinner: Capt & Mrs Brad Kaplan, Office of Liaison Administration
19 August, Sunday: Transit to Vietnam

Report 5: 19-23 August 2001: Vietnam
A Vietnam Observations
B. Vietnam Visits
C. Comments and Suggestions
Itinerary

A. Vietnam Observations

Lengthy colonization, followed since the mid-part of the 20th century by two decades of war against major western powers, then in the mid-70s by reunification under a Communist system and more than a decade of tightly controlled state planning, have not been without an impact on Vietnam's S&T enterprise. Essentially, most of the infrastructure was destroyed, and the few remaining academics were educated in Russia, or Eastern Europe. Although there has been considerable modification and upgrade of the resulting debilitated and Soviet style S&T system since the government's policy of 'doi moi' (renovation) was initiated in 1986, there remain some significant deficiencies. To quote from the abstract of an extremely informative study of the system and its changes, "the impact of doi moi policy in the area of S&T must be described as ambiguous: There is an incongruity between successful structural changes and their functional effects, in particular regarding increased innovation activities - which have so far not or only partially been achieved. Some serious problems in the science system, in industrial enterprises as targets of innovations and in infrastructural prerequisites for innovation diminish Vietnam's current and future potential to utilize R&D for economic growth and social welfare.[21]"

Efforts to liberalize the economy, attract FDI, restructure State Owned Enterprises, and build an associated basis in law to support the evolving socialized yet market-based system continue; they are the subject not only of daily articles in the papers, but of frequent legislation. Changes in administration, organization, policies and law affecting innovative capacity in universities, government research institutions and industry are part of the process[22]. Among the significant changes are:
- continued pressure for more applied work and technology transfer, with an associated de-emphasis upon basic research (the style -- economic vice political -- but not substance of this pressure has changed over the last decade)
- a mandate for research institute-university interaction (breaking down the old Soviet-style system of separation of teaching and research)
- pressure on industry to innovate and participate in R&D (the Government-Industry balance is now between 80/20 and 70/30, pretty much the inverse of that in Japan and the US)
- priorities set at the level of the PM, Ministries, and Institutes; both in terms of areas of focus, and even quite specifically in creation of a system of 30+ national "Key Laboratories" (each to be funded at @US$3M over 3 years) throughout the country[23]

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[21] Meske, Werner, & Dang Duy Thinh, Directors and editors, *Vietnam's Research and Development System in the 1990's: Structural and Functional Change,* Wissenschaftszentrums Berlin fur Sozialforschung Research Report P 00-401, Berlin, Dec 2000. I strongly urge the US representatives to the Committee for the US-VN S&T agreement to read this document prior to their November meeting

[22] E.g., a new Law on Education in 1999, and Law on S&T in 2000…again, required reading, I would suggest, prior to the upcoming meeting

[23] We were told in many places that the top priorities are **IT, BT, automation, and materials** (huge simplification here - each is caveated and explicated to refer to national strengths in a very perceptive way). Details, we are told, are available in their announcement (we would call it a BAA or RFP) of opportunities for any institute (university, GRI, industry) to propose -- which, we were told, was available but only in Vietnamese, on one of two web sites: www.vista.gov.vn, or www.moste.gov.vn. More

- competition, albeit still somewhat constrained -- and without international (or even external) participation in the review process (in marked contrast to say Hong Kong) -- for National and Ministerial projects (as opposed to just assigning projects to various labs)
- recognition of the urgent need to address human resource issues, from abandoning the flat-salary approach to funding government researchers and educators (at a level of about a third to half of what they need to survive…guess the consequences), to the likely retirement of up to half of the senior scientific cadre in the next decade (with problematic follow-on)
- a fundamental shift from Soviet to western practices and education, while attempting to capitalize on abundant indigenous resources, including great respect (if not reward) for advanced education[24], appreciation of the natural geographic and biological richness and diversity of the country, and a deep concern -- notably and forcefully in the Military -- for remediation of past chemical and other (e.g., unexploded ordnance) residues of industry and war.

In a way, this is the hardest report that I have had to write so far. First, because there are so many (recognized) structural deficiencies in the S&T system that it is impossible to encourage extensive cooperation for other than strategic or economic purposes. Perhaps most importantly, as in the Philippines, what's lacking in VN in terms of collaborative opportunity is the infrastructure that permits both breadth and depth of investigation. This is indeed appreciated by the Vietnamese, and is one reason for the Key Labs program and similar initiatives…they realize that S&T instrumentation and computational capability must at a very bare minimum exceed what's expected from industry. You can't expect researchers to lead from behind. Given their investments this situation may be different in some fields in a few years, but for now the major interest from the standpoint of mutual benefit must be in asymmetric approaches or natural indigenous resources[25].

Second, it is hard to add much if anything to the work of the VN National Institute for Science and Technology Policy and Strategy Studies (NISTPASS), see footnote 1 for an example of their excellent research. NISTPASS has strong connections to very capable international S&T policy groups (indeed they coordinated a 1999 international experts' review of their S&T situation - again, EST should try to get a copy) and their papers can do much more than I to provide very perceptive, open and impartial (indeed highly critical) studies. Third, our agenda was largely determined by the VN Government, and tightly constrained by both time and other visiting delegations (there is a lot of international traffic…); and while I find no cause to complain about the openness of our hosts and their willingness to discuss their issues and interests, we sampled only a very small segment of their capabilities -- essentially, just one Ministry (MOSTE), and the National Center for Natural Sciences and Technology (and just 3 of its 17 Institutes, and them only briefly) -- so the visit lacked diversity as well as depth in what we have seen.

There is also an issue of timing. While VN has been actively working to 'renovate' its R&D structure and economy since even before the breakup of the Soviet Union, and has experienced many ups and downs in the process, there is now significant do-or-die pressure. Two factors

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mandatory reading, and in this case I strongly suggest DOS request an English version from the excellent translator we had in Hanoi, and add it to the required reading list. The details of what they're doing, and what they will propose, were not available to us; but there is much information that should be exploited before the next official engagement..

[24] We heard several stories about families, or even whole villages, contributing to the education of a promising young person

[25] For example, during our visit a team from Trippler Army hospital was visiting to try to conclude previously discussed collaborations with a Vietnamese Army hospital, with particular interest in their use of acupuncture for anesthesia, and tropical diseases.

contribute to this: the pending US-VN trade agreement which requires additional near-term adjustments, and the ASEAN Free Trade Area which is scheduled for implementation in 2006. The US-VN S&T meeting scheduled for this November also contributes a bit to the pressure to complete the transition, although as in most developing countries, the leading issues are economy and trade, not S&T, even though they are so intimately connected. To borrow again from the NISTPASS work, "it is not yet clear whether the 'tiger scenario' or the 'transformation scenario' will be followed[26]…which scenario will become reality depends mainly on what can be achieved in the time remaining before the opening of markets. Time pressure is now paramount[27]". From the perspective of S&T, the critical issue is how well innovation can be used to impact the economy. Thus for a while, the sort of 'long term, Navy & MC after next' approach of places like ONR will receive little attention; for the next few years at least, cooperation needs to focus on "something that they need", to quote our DATT. This does not of course mean that there are not some interesting opportunities, some of which I discuss below; it simply shapes the environment for interaction.

Thus to do less than justice to an extremely interesting and complex situation, I'd make the following observations (many of which have not been justified by the above comments):
- The S&T strengths in VN remain largely in the Research Institutes; over the next few years these will selectively grow or wither depending upon investment decisions and policy related changes; but the focus will be almost exclusively on applied research, and technology transfer or development of spin-off companies[28]. The four areas selected for emphasis are IT (software industry…the head of one of the Institutes I visited was in India during my trip), biotechnology (largely focused on agriculture[29]), automation, and new materials. VN intends to rely on importing technology through FDI, cooperation, and foreign-made lab equipment for some time to come; indigenous contributions to and with these imported resources will focus on local needs and capabilities[30].
- Research Institutes practice a curious amalgam of research, teaching, and commerce; under the communist system it is hard to say where one activity stops and the other starts; but clearly, all the government institutes are focused on creating economic and social benefit for the nation, by whatever means.
- Although there is talk here as elsewhere about the 'knowledge society', and VN made IT and the software industry a priority in 1993, computer literacy is low, connectivity poor, and telecommunications very expensive (they plan their own satellite both because of cost and concern with channel availability); yet telecommunications, partly for 'security' reasons, remains one of the SOE bastions.
- Although the country has now been 'at peace' for over a decade, there are residual issues with some of the 54 ethnic groups, and lingering suspicions with both ourselves and some of their neighbors. Security concerns still play a role in their decisions on what information and capabilities to share (e.g., only in the last couple years have international groups been able to

[26] The first refers to increasing industrialization and rapid economic growth, the second to changes along eastern European lines, where free market opening led first to massive setbacks in industrial production.
[27] Op cit 1, p 264
[28] NCNST states that basic research in math, physics, etc remains one of their strengths, both because of the prestige accorded scientists, and their excellent training in fundamentals under the Soviet approach to education. However most 'basic' researchers have been encouraged, if only by lack of project funding, to consider applied problems.
[29] VN is the 2nd largest exporter of rice and coffee, and about 5th for fish. Agriculture occupies 70% of the work force and provides some 25% of GDP, compared to 35% for industry and 40% for services
[30] E.g., an example of the application of 'new materials' we were shown, was the use of composites for prosthetics sized to the local population

provide the capability to get severe weather warnings to the villages and fishermen). The military however is purely defensive; as noted below, in our discussions they focused entirely on issues such as environmental remediation of agent orange, decontamination of chemicals left over from the war, demining, and health care and tropical diseases[31].
- There is significant competition for VN's attention and cooperation in S&T, with the leading contenders seeming to be Germany and Korea. Japan is also playing a strong role, possibly for the same reason that it is working on IT with the Philippines (pending labor shortage). Relationships with China are less close than those of any other country I have visited; exchanges seem limited to DV, protocol-oriented visits.
- Marine and coastal regions are recognized as important for both social and economic reasons, but are not among their top priorities. On the other hand, there is a general appreciation of the extreme importance of the environment for VN's future. Its agriculture, fisheries, and geographic, biological, and cultural diversity are among its greatest strengths; and while some SOEs and many SMEs pay little if any attention to environmental protection (e.g., a newspaper article severely criticized conditions in many of the small tin mines), on a national basis there is an appreciation that environmental propriety is closely connected to economic strength.

B. Vietnam Visits:

MOSTE: The Ministry of Science, technology and Environment, founded in 1959 and operating since under several different names, "is a Government Body performing the function of state management in the fields of scientific research, technological development, standardization, industrial property and environmental protection" (from its brochure). It formulates laws (including the 2000 Law on S&T - again, this is a document the Embassy EST section should be asked to provide prior to the November meeting), policies, strategies and plans, and is also responsible for environmental protection. Although MOSTE is only one of the Ministries responsible for S&T[32], it has the major coordinating and policy development role on the national level. My hosts described the major national priorities -- IT (software development), BT (focused on agriculture), automation, and new materials -- related them to indigenous capabilities and needs, and described recent changes in their S&T system.

The budgetary objective for S&T is 2% (S&T funding has been closer to 1% of budget, and a small fraction of a percent of GDP); the government now supports only programs of national importance that have an impact on society (beyond the salaries of the government employees at the various research institutes, and what we would call overhead…), as opposed to the previous allocation of all funds by head count. All programs are open to competition among

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[31] US and VN have recently reached agreement on agent orange research; a US demining contingent was in country at the same time as we were, to help install a computer-based planning and training system. More on water-related demining below.

[32] There is also a National Council for S&T Policies, established at MOSTE's recommendation in 1992, whose senior members 'act as individual scientists', not as agency representatives, to advise the Prime Minister on priorities, major policies, and draft versions of laws regarding S&T. Other Ministries with S&T programs include Health, Agriculture and Rural Development, Industry, Education and Training, Finance, and Planning and Investment (notably, not defense) . Each has its own set of Research Institutes. State Owned Enterprises (SOEs) such as Petro Vietnam, Vietnam Posts and Telecommunications, and the Vietnam National Steel Corporation, also have their own Research Institutes. In addition, NCNST (see below) and its companion National Center for Social Sciences and Humanities, each of which has several institutes, report separately to the government, albeit they are under budgetary and operational control of MOSTE, the Ministry of Finance, and the Ministry of Planning and Investment. Overall, the NISTPASS report lists some 102 Tertiary educational institutions, and over 600 R&D organizations, with a total of almost 20,000 scientists and engineers.

research institutes from industry and universities as well as the Ministerial Research Institutes. They emphasized that VN will enter the ASEAN Free Trade Area in 2006, which puts pressure on them to introduce new technologies to make Vietnamese products competitive. The focus is thus on applied technology and tech transfer, and on business, not simply the S&T organizations; S&T policy mechanisms are coupled with tax incentives, industrial estate schemes, and similar inducements for the introduction of new technology-based products; and state ownership will be retained only where 'essential'[33]. They will publish "S&T Activity for the Period 1996-2000" this October; the EST section should be asked to obtain a copy to support the November meeting.

In addition to their policy functions, MOSTE "manages" S&T in 14 industries, including transport, chemicals, energy, IT, mining, food processing, and oil and gas (some of these sectors are under other Ministries, and the lines of responsibility are not at all clear to me; I believe that the other Ministries have their own Research Institutes, while MOSTE is responsible for the research actually conducted by R&D units in industry). My host was in charge of electronics, IT, and telecommunications, and described their program to launch a telecommunications satellite by 2003/4, at an estimated costs of US $300-400M. I asked why they needed their own, and he responded that rental costs are extremely high, and there are limitations on channel availability. They also are interested in their own remote sensing satellite, and have sent a team to the UK to discuss their small, inexpensive satellites like the one now used by Malaysia. Also, they are working with the Ministry of Trade to establish e-commerce under the framework of ASEAN. They will need to modify their laws and regulations as well as communications infrastructure to achieve this objective.

MOSTE also has international cooperation responsibilities (most agencies and institutes have 'International Relations Departments…I don't understand how all these interact, but it appears to be very similar to the system in the Soviet Union). They have bilateral relationships in S&T with some 70 countries; they used to receive "one-way" support from the socialist countries, but now understand that they must themselves provide some support; for example, if they are given state of the art equipment, they will need to provide for its facility, operations and maintenance, and training. They envision four main forms of cooperation: joint research for mutual benefit, technology transfer, training and capability enhancement, and information and scientist exchange. They are particularly anxious to learn from the developed countries, and have focused on cooperation with Japan, Korea, and Western Europe, now hopefully also with the US. There are explicit provisions to encourage international cooperation in their major new national programs (again, we should get a translation of the associated paper from their web site); this was one element that was considered in selecting performers.

NISTPASS: The National Institute for S&T Policy and Strategy Studies, with 76 staff members, reports to MOSTE and is responsible for research into S&T policy and impacts, and advice to the government on practical implementation. They cited the Law on S&T, Vietnam's 2020 Vision, and the S&T Strategy to 2010 (additional documents it would be good to have before November) as major recent achievements. They also described a number of interesting studies, including the one I have cited; their major current research is on 'strengthening technological innovation in the context of globalization and Vietnamese liberalization'. They intend to conduct a Foresight study, more to involve the S&T community in the S&T planning process than for its actual results. Many of their studies are done in conjunction with, or with support from, Canada, Sweden, and Germany. We had a stimulating discussion with Dr Dang Duy Thinh, Vice

[33] One of these is likely to be Post and Telecommunications, although there is considerable pressure to open up the telecommunications market. For a country that says that IT is one of its objectives, their infrastructure for even telephonic communications not to mention computer and data connections, is terrible. As in many other fundamental areas, e.g. transportation, the infrastructure is woefully inadequate. If telecommunications remains a monopoly, it is hard to envision how VN will successfully 'renovate'.

Director, and Dr Bach Tan Sinh (who has degrees from Germany, Sweden and Denmark, and just finished a post-doc at Berkeley). They appear to have a very good understanding of both strengths and weaknesses in the VN system, and are realistic about the magnitude of the challenges facing the country. They emphasized that a major strength is Vietnamese traditional knowledge and the country's extremely rich biodiversity; VN obviously can't compete head-on in technology with the likes of US and Japan, and needs to emphasize their competitive advantages which also include strength in math and physics, and manual dexterity and the ability to observe and reproduce what they see, as well as their natural conditions. I found this to be a very impressive Institute and would suggest that collaboration with NISTPASS scientists in S&T policy and strategy studies be considered as one aspect of our S&T cooperation. Not only are the scientists I talked to of the caliber we would like to work with, but such research would keep us close to the center of Vietnamese S&T policy. Further, NISTPASS, like the NCNST Institutes, are authorized to offer MS and PhD degrees[34]; thus students could be involved in any collaboration[35].

NACENTECH: The National Center for Technology Progress is a Research Institute that was established in 1984 and has been under MOSTE since 1994. It is responsible for "research and development, technology transfer and education, pilot production and full scale production, services and business, personal training and international cooperation…" (brochure) in medical and industrial lasers (we saw a brochure of their products), ASIC technology and electronic components (e.g., LEDs for advertising), new materials (medical composites for prosthetics, bone replacements, burn and wound treatment), IT, and BT for agriculture and industry (fertilizer). They have 6 R&D centers with 500 'skilled scientists', plus an import-export company to commercialize their products. They focus on importing technology, and modifying it to VN conditions; over time, they will develop and introduce their own S&T, but for now they need to built an expanded technology base by bringing in technology from others, and offering local facilities for its modification and test in Vietnam. The facility we visited was called VIKOTECH, VN-Korea Technology Cooperation Center, to which each side had committed $3M. It is a computer network (all the equipment had Korean seals) that they want to use for technology transfer and e-commerce; it will be operational in December; essentially, it will offer business-service relationships. Given Korea's emphasis on web connectivity throughout their own country, this center will serve as a useful portal for their (and others') dealings with Vietnam.

NCNST (or NCST): The National Centre for Natural Sciences and Technology is one of the two leading 'independent' (i.e. reporting to the PM) S&T organizations in the country (the other deals with social sciences). It was founded in 1975 as the "National Centre for Scientific Research" and changed its focus and title toward more applied ends in 1993. We were briefed by Prof Son, Head of the Planning and Finance Department, who had just been selected as their new Deputy Director; we also visited three of the 17 Institutes, 9 sub-institutes, and 16 spin-off enterprises and

[34] The MS degrees must be offered in conjunction with a University; this regulation is supposed to improve the connectivity between Universities and Research Institutes and break down the old Soviet style system. Indeed many researchers we talked to do teach, albeit the degree of 'integration' is doubtful at this point.

[35] Student involvement in any collaboration stemming from our agreement is particularly important, in my mind, in view of the recently established US Educational Trust Fund -- $5M/year for 16 years -- for MS and PhD studies by VN students in US universities in S&T and medicine. This opportunity will greatly expand the opportunities for collaboration with Vietnamese scientists and, in the long run, have an impact on their approach to research. If such education could simultaneously be incorporated into research projects through thesis topics, then the student-professor collaborations that come naturally from education could be enhanced and extended by US researcher to VN researcher ties.

companies. NCNST is responsible for R&D in 'priority fields of technology', improving the nation's S&T potential (i.e., it offers MS and PhD degrees), and international cooperation. It has 2380 staff, of which 205 are Professors/Associate Professors (a designation recommended by the Centre based on active involvement in education, and approved by the "General Committee for Scientific Titles"), and 700 DSc or PhDs; there are about 250 MS and 150 PhD students. The main strengths of NCNST, we were told, are in IT, BT, materials, biological resources and ecology, earth science including oceanography, maritime engineering (support of the offshore oil industry), and basic research in math, physics and chemistry. In addition to their interaction with the RAS and other Eastern European research organizations, they cooperate with CNRS, CSIRO, JSPS, and KOSEF. Discussions with China have increased over the past year, and there may soon be a cooperative agreement.

In 2000, NCNST conducted 23 National Research projects (large), 150 national basic research projects (small) and 120 projects at the Ministerial level. Salaries were about 23B VND; the research budget was 38B VND. They also received 25B for capital construction (for the Institute of Chemistry, the Institute of Oceanography at Nhatrang, the Institute of Ecology and Biological resources, and the to-be-established Institute of Environmental Technology), and 36.5B for instrumentation -- the first major investment in this area (used principally for chemical technology and material science). They also successfully competed for two Key Labs - Gene Technology, and software development (where they receive advice from KOSEF); each will receive 50B VND over 3 years. The recent Party conference decided that S&T will receive increased investment; they expect that resources will increase, and they will have more autonomy in terms of budget, encouraging technology transfer to industry and motivation in terms of salary levels (as noted earlier, researcher salaries are inadequate for even basic needs; they derive extra income from 'tutoring', research projects, or other activities). At issue is how better to combine S&T and production; one impediment is that industry by and large is not interested in S&T, nor is the S&T capability so strong that it can rapidly produce the results industry may want (these structural problems were echoed in the NISTPASS study). Further, there are also some impediments from the Ministries themselves, e.g. regulations regarding testing of new medicines.

Most of the Hanoi NCNST institutes are grouped together in a large compound on the outskirts of town. The Institute of Physics, which we visited, is located downtown. Its Materials Sciences division was broken off in 1993, and it now has labs for theoretical physics (20 PhDs…this group is hurting and decreasing given the move toward applied work), nuclear physics (there is an accelerator in Hanoi), quantum electronics (photonics, lasers), and remote sensing (using MODIS data). There is an Environmental Physics group in Ho Chi Minh City. Their educational partner for the MS degree is Hanoi Teaching College, and they also collaborated with the National University of Hanoi, and the Cancer Hospital. Our host, the Institute Director, discussed the problem of low salaries and support - e.g., his own research groups gets less than $900/year to support their work. He asked if our cooperative programs have provisions for providing them journals.

The Institute of Biotechnology was much more upbeat, albeit with just the bare minimum of equipment needed for modern research. Our host Dr Hai, Head of the Laboratory of Applied DNA Technology, had his PhD from Russia, and several years of PostDoc experience in Germany and Japan. Most of his previous work has been on plants, but he is shifting to study the resistance and susceptibility of VN peoples (recall there are 54 'recognized' ethnic groups) to various diseases. This Institute has 22 laboratories; the brochure states that its principal research activities are in molecular biology and genetic engineering, biology of microorganisms, and enzyme, animal and plant biotechnology. The Director, Dr Binh, also heads the lab of Plant Cell Biotechnology, and has developed drought and cold resistant strains of rice that are now in use. Dr Hai noted that overall they has a 'minimal' but adequate capability in terms of

instrumentation, but that the new Key Lab in Gene Technology will help greatly. We toured their simple but clean and well cared for facilities.

The Institute of Geography has 150 staff, 50 with MS or PhD, and three main divisions: Water resources and Environment, Geographical Environment and Territorial Organization, and a Branch in Ho Chi Minh City. Research covers surface, ground, and river water; climatology, biogeography and ecology; and G&G, socio-economic geography, and environmental impact. Programs of national interest include studies of coastal regions and islands for socioeconomic development, avoiding desertification in the south-central region, and management of natural resources for environmental protection and development. One problem, for example, is "professional" villages in the south that generate much waste. In spite of the rainfall, in fact, there are problems with adequate good quality water due to a combination of the dry season, floods, poor management and disposal practices, and salt water intrusion in coastal regions. Our host stated that they had good digitized aerial photo coverage of the country, and were working with Japan on a study of land use change (this may be of interest in the context of some of the work I was involved in before this trip).

MOD: Accompanied by the DATT, Army LTC Frank Miler, we met with senior members of the MOD Technology section (no name cards; LTC Miller knows the VN participants well, and can provide further information and contacts if necessary). Most of this meeting involved my briefing them on ONR and its programs. They stated quite emphatically that their priorities are associated with environmental remediation (agent orange, chemicals, demining), and health. LTC Miller noted that the military these days is purely defensive. Gary Vest of USD(ES) had visited a year or so ago, and discussed base cleanup; follow-up action has apparently been assigned to the Air Force (Col Bostick?), who has re-submitted a proposal for some funding for this type of activity. Our current cooperation consists essentially of humanitarian demining and some medical interactions (e.g., NMRU is conducting some training in Vung Tau); we are apparently unable to use military engineers (USACE) for overseas cleanup because of priority restrictions under BRAC laws. On the way back to the hotel we stopped by a lake in the center of Hanoi where the Army is conducting demining operations; they have laid out a rope grip, and are using metal detectors from rubber boats to attempt to locate unexploded ordnance. See picture below:

I comment further below on potential opportunities for experimentation.

C. Comments and Suggestions:

As noted above, there have been many US (as well as other international) delegations to Vietnam this summer, some of which at least are designed to provide input to the November meeting of the committee to discuss actions under the US-VN S&T Agreement. Perhaps because of that pending meeting, several of our hosts were unwilling to be specific about their interests for cooperation,

stating that management is in the process of reviewing recommendations. In my limited time I was also unable to get any significant details on specific projects at either the National or the Ministerial level, although from the discussions at NCNST, for example, it is clear that they exist and form the basis for their competitive awards. At least for MOSTE and National programs, this information, we were told, is openly available on their web site (again, see www.vista.gov.vn and www.moste.gov.vn), but only in Vietnamese. I would strongly recommend that the EST section of the Embassy be asked to arrange for a translation in advance of the meeting. Another piece of valuable information would be the identity, location, and Pis for each of the Key Laboratories that have already been selected, and the topics and selection dates for the ones yet to be decided. Since each of those Key Labs will receive a significant infusion of infrastructure funds (e.g. the Gene Technology lab at the BT Institute of NCNST is receiving US $3M for instrumentation), and thus will become the likely center of VN S&T capability for the next decade or so, that information will help us pinpoint the best opportunities for truly collaborative efforts. Again, the Embassy staff should be able to get this information relatively easily, as well as additional reports from NISTPASS that should shed light on potential structural changes, and strengths and weaknesses.

S&T policy and strategy itself would appear to be a worthwhile area for cooperative research. There are some very interesting issues, and I was impressed with the caliber of the work done by NISTPASS and its current collaborators, and by the acumen of its staff. Some of my earlier reports discussed similar S&T policy and strategy efforts in other countries (see, e.g. 3A about Japan's NISTEP, and 4 about KISTEP), so that to my mind at least there would appear to be a rich opportunity for multi-lateral and comparative studies, that would be of both academic interest and useful for all parties' decision makers. This topic of course is of more interest to DOS and perhaps NAS, than to ONR.

As already noted there have been several military delegations in town recently. Lacking any formal basis for mil-mil cooperation, we are generally limited to humanitarian actions, and to opportunities for training (e.g., doctor training in some interesting indigenous techniques; demining training). Further, the military per se has little if any R&D capability, and stated their priorities as remediation of agent orange and chemical substances on ex-US/RVN bases, demining, and health care and tropical diseases. I have earlier noted that VN is a potential alternate site for a NMRU. We may also be interested in the activities of the VN-Russian Tropical Research Institute (located in the Hanoi outskirts, around the corner from NCNST), which apparently does some interesting work on vehicle and machinery operations and storage in tropical environments.

Organizations such as NOAA (NWS, NMFS, etc), EPA, DOA and others concerned with environmental studies should, in my opinion, find much of interest here. Again, VN has a wealth of environmental variability of almost all types, as well as being highly susceptible to weather-based disasters. Also, one of the labs of the Institute of Physics is starting to receive and use MODIS data, and both that Institute and remote sensing departments of the Institute of Geography displayed considerable interest in satellite data applications; they appear to be stopped largely by the cost of such data, but if there was interest in collaborative work with NESDIS or NASA or USGS, some further research-oriented access may be appropriate. Of particular interest to me is a joint program between the Institute of Geography and Japan (NFI) on land use change over 5-year periods from the 70's; they are using largely aerial photographs. The LANDSAT-based ~1990 map and derived land-use information recently produced by EARTHSAT, and associated GIS-based environmental security products, would be very useful to them for this and many similar programs associated with environmental protection and agriculture. I suggest that if

this fits into any of the US interest areas for the November meeting, that Andy Reynolds discuss opportunities with Doug Way. My sense if that the overall broad topic of environmental I&W, protection, and remediation could be the focus of a very interesting US multi-agency cooperative program with Vietnam, if there is interest by the associated agencies and their researchers.

I didn't have the opportunity to discuss disaster management (which is of course closely related to the above) with any knowledgeable local hosts, but would expect that VN participation in PACOM's training and information programs, plus other SE Asian disaster planning and mitigation networks, would be a fruitful area of interaction if they are not already involved. Similarly, PACON membership might be another useful mechanism for multilateral ocean-oriented S&T; I can't recall from my participation at the PACON 2001 San Francisco meeting, and discussions with Dr Saxena, whether there is a Vietnamese Chapter. Gary Jensen may wish to follow-up, and if they are not already a member, then perhaps the IFO could include this opportunity in future interactions, if ONR decides to pursue any opportunities in or with VN.

I believe that there are two areas of ONR interest worth pursuing. The first , not surprisingly, is coastal oceanography. Following Hassan Ali's visit a couple months ago, IFO is sponsoring three VN scientists from the Institute of Oceanography to attend this year's IOC WESTPAC meeting in Seoul next month. This will offer an opportunity for further discussion; Dr Edsall has already started to open channels of communication with interested US researchers, and will report on same as the discussions progress. Recalling (Report 4) that the UPD's MSI has already had some at sea collaboration with the VN IO (and the plans for extending the HKUST coupled model), and noting the interest expressed at both MOSTE and NCNST in coastal and marine science, and in the offshore islands, there may well be opportunities for both bi- and multilateral research with Vietnam, extending from their major rivers and harbors through the SCS.

A second and somewhat closely connected area for possible collaborative research is MCM. One of the Haiphong channels remains closed due to unexploded ordnance, and the Vietnamese continue to de-mine water as well as land areas; the attached photo shows this in process in a small lake in a park in Hanoi; soldiers in rubber boats are using metal detectors from the surface to laboriously work their way through a rope-grid. It occurs to me that if ONR is looking for opportunities for experimentation and demonstration of some of the new mine detection technologies, or for studies of mine burial, then there is a 'natural laboratory' of sorts in the waters of Vietnam. I recognize that there are significant pol-mil aspects of such a project, and that there are distinctions between military assistance, cooperative R&D, and S&T, but on the other hand if we are looking for places to test our evolving equipment and techniques in challenging waters, then Haiphong and the Hanoi lakes may well be an interesting opportunity. This and the other potential oceanographic projects should be discussed at the London all-hands.

Itinerary

19 August, Sunday: Arrive Hanoi, taxi to Daewoo Hotel

20 August, Monday: AM: Meet with EST Officer, Gary Sigmon

PM: Ministry of Science, Technology and Environment (MOSTE); National S&T Policy Council; National Institute of S&T Policy and Strategic Studies

21 August, Tuesday: AM: MOSTE, Institute of Technological Research and Application

PM: national Center for Natural Science and Technology (NCNST) Institutes of Physics, Biotechnology, and Geography

Dinner: Mr. Sigmon and Vietmanese guests from MOSTE

22 August, Wednesday: AM: NCNST

PM: MOD with LTC Frank Miller

23 August, Thursday: Report Preparation; Transit to Bangkok

Report 6: 23-31August 2001: Thailand, Malaysia
A. Thailand: Observations, Visits, Comments & Suggestions
B. Malaysia: Observations, Visits, Comments & Suggestions
Itinerary

A.1. Thailand Observations:

This was my first visit to Thailand. I had a very diverse set of meetings with both national and international organizations, and an excellent brief -- best yet -- by the Country Team. My overall impression is that the country presents some interesting contrasts, and unusual, challenging opportunities for US S&T interactions.

Although the economy has not recovered very well since the economic crisis in 1997, Bangkok bustles with traffic, consumers, and happy well-fed people; the limited amount of countryside I visited was likewise in good condition compared to some of the other developing nations I have visited on this trip (albeit overall the environment is heavily degraded -- deforestation, pollution, etc), and there are plenty of tourists (good shopping!!). The economy continues to struggle in part because of its dependence on exports, as US and Japanese markets slow down (it had a trade deficit in the first part of this year). Development of domestic markets is a priority, along with "(1) stability of the economy, (2) equality of distribution of growth, and (3) high performance, knowledge based, and creative economy[36]" under the 'populist' government of PM Thaksin Shinawatra, a telecommunications entrepreneur (recently acquitted of disguising his assets).

The new economic development strategy acknowledges that "the Thai economy has excessively relied on foreign capital and technologies, and low wages of unskilled labor". Further, much of the development has been in Bangkok and a few other cities, and industrial estates. The majority of the population remains agricultural, and Thailand is still the world's #1 rice exporter. The strategy sets out a number of fiscal and financial actions to manage current problems, plus 'measures to strengthen society and economic foundation…and fix domestic problems that hampered the economy'. By and large, these focus on the villages and countering poverty (1MBaht -- about US $25K -- to each of the 79,754 villages; marketing local products; a health insurance scheme), and relatively low technology industry (tourism, SMEs -- to develop design capabilities and upgrade 2nd and 3rd tier suppliers to the major foreign industries -- and construction), while encouraging export and minimizing the requirements for foreign currencies and imports. The strategy recognizes the need for sustainable growth, quality over quantity, human and natural resources, S&T and IT, and environmental quality, and calls for the development over the next 1-3 months of action plans for each of its initiatives.

However - and it's a big however - as I was told time and again, Thai's are big on goals and objectives, and weak on concrete plans and follow-through. Further, the constitution provides for public participation and debate before the government decides on specific actions, and there are many active NGOs and a vocal media that can drag out the decision making process, and have major impact on ultimate policy decisions. One current issue under public discussion, for example, is use of GMOs; another is whether to allow shrimp farming on rice fields (higher value, but salt water impact); a third is where to start to count the 12 years of free education called for in the 1999 National Education Act. So, while the strategy may sound reasonable

[36] *Strategy Plan Framework: Toward Quality and Sustainability of Thailand Economic Development,* Ministry of Finance, National Economic and Social Development Board, July 2001

overall, there is considerable skepticism about whether many of the major structural elements -- beyond those populist measures that were key electoral promises -- will be implemented.

There are also what seem to me to be many incongruities, and unaddressed structural impediments to long term economic growth. For example there are still some significant constraints on FDI and foreign ownership; Thai's make it plain that foreigners are indeed foreigners, and Thailand is for the Thai's[37]. There is a lot of government control of significant elements of industry and infrastructure, either through state ownership or monopolistic concessions (including telecommunications). And Thailand clearly does not see S&T as critical to its future, at least not with the same degree of commitment and resources as many of its Asian neighbors. S&T for IT, for example, means developing a capability to design some chips for specific applications, or to produce software in the Thai language[38]; biotech development focuses on rice strains, shrimp vaccines, and tapioca starch products. They are definitely not shooting for the 'big leagues', witness the total government R&D budget of about 10B Baht (~$250m)[39]. Not to mention that Thailand came in dead last in a recent international ranking of 49 countries in S&T development. Given attitudes and investment strategies or the current government, it's likely to stay there.

On the other hand, Thailand is by no means an impoverished country. The roads are decent in general (if clogged and confusing in Bangkok), fuel is cheap, the tax base is reasonably sound, and there continues to be considerable foreign interest (e.g., NSTDA's two-year old software estate on the edge of Bangkok filled up quickly) due to reasonably well educated, hard working, trainable, inexpensive labor, and not unpleasant living conditions. There is a lot to work with. One of the incongruities is that there are significant strengths that seem to be overlooked or ignored in the strategic plan, as best I can tell from my discussions and readings. One is medicine. There is an extensive public health system, and some of the best, least expensive medical treatment in the world is available in Bangkok's private hospitals; they already attract much international trade. Yet other than 30-baht insurance, there seems to be no intent to capitalize on this capability. Similarly, there is a lot of talk about 'local wisdom' and herbs, but no effort (as compared say to Hong Kong) to systematically investigate efficacy or use BT to exploit such natural resources. Textiles are strong - cotton as well as the famous Thai silk; but there are no plans that I have seen to increase efficiency or develop new textile or silk based products. There are 24 public[40] and 50 private colleges and universities, a number of government research institutions, and a lot of international companies that -- it seems to me -- may well be able to take advantage of 'local wisdom' and in-situ R&D. Yet, none of these seem to figure into the plans in any way whatsoever (yes, there is the National Education Act and nice words about

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[37] on a micro as well as macro scale; e.g., only foreigners are charged entry into tourist attractions; there are separate stalls for Thai and foreign shoes at the entrances to popular Wats; Thai women who marry foreigners lose many of their rights; foreigners can buy a condo but not a house and land.

[38] A summary provided by the Embassy notes that the Thai IT industry is large and growing, accounting for about 16% of manufacturing output and almost 30% of Thai exports; investments continue, including Sony's plans to move all its semi-conducting manufacturing to Thailand. The previous government planned to initiate, and take a significant equity interest in, a $1.2B 'wafer' project to upgrade the industry from its current basis in assembly; however the current government has backed away from this plan, and the project is on hold white attention is shifting to building an IC design capability.

[39] NSTDA's budget - see Visits section - went down from 2B Baht last year to 1.6B this year. We were told that everyone got cut in order to give the PM a 'pot' of about 60B Baht that he can dole out to support proposals in line with his objectives. This is just one symptom of increasingly centralized control.

[40] Including the 2 'open' universities in Bangkok that have an astounding total of over 560,000 students, with 1200 academic staff.

human resources, but they seem disconnected from the economic strategy). I may well be missing something fundamental here. But if I'm not, then I simply don't understand the rationale for the non-fiscal part of the strategy, beyond its very apparent populist and nationalist elements. It certainly is light on S&T.

Thailand does however have resources that should not be overlooked for S&T interaction, namely its multinational institutions. For example UNICEF is here, also the APEC Technology Foresight Center and many NGOs. Bangkok has long been a comfortable, convenient base of operations for international organizations. Of particular interest to me were two projects initially started by SEATO (see Visits) -- the Armed Forces Research Institute of Medical Studies (AFRIMS) and the Asian Institute of Technology (AIT) -- and the Asian Disaster Preparedness Center (ADPC). Thailand also has a volunteer military that is well respected in the country, and has considerable operational, planning, and training capability, plus some 37 military hospitals (that treat civilians as well as military), as well as the Thai component of AFRIMS. Thus as a base for multilateralism, in particular for technology strategy, of for humanitarian or environmental issues, Thailand has excellent resources. Perhaps for many of the same reasons that it has been able to attract considerable foreign investment, and in spite of the PMs populist, occasionally exclusivist rhetoric, the country seems to provide a climate in which international outreach thrives. And, with its capable and respected military, Thailand could play a significant role in 'enhanced regional engagement' if appropriately encouraged and supported.

A.2. Thailand Visits:

MRDC: The Royal Thai Armed Force's Supreme Command's Military Research and Development Center was initially established as a joint US-Thai Combat Development and Test Center in 1961. It got its current name in 1963, and then became a Thai unit when the US contingent phased out in 1972. It has Combat, Materiel, and Communications and Electronics R&D Divisions that are responsible for tactics, doctrine, and evaluation and reports in their respective areas. After my hosts described their mission and organization and I briefed ONR's programs, they stated that their current areas of interest are border surveillance, renewable energy, GIS, ionospheric studies (they have been taking propagation measurements with the Australians for 7 years), mine clearance alternatives to anti-personnel mines, and joint doctrine. They do no S&T in the sense we mean it, rather all work is applied, and they are seeking help with inexpensive technologies that are adaptable to their environment and operations. We described APAN[41], with which they were not familiar, and discussed the possible use of IMET for education or training in some of their areas of interest, e.g. GIS.

NRDO: In addition to MRDC, each service has its own R&D organization that reports through its Chief of Staff to MOD. Navy's R&D Office, with a staff of about 100 and a budget of about 6-7M Baht, is responsible for managing, and to a much lesser extent performing, doctrinal, materiel and technical development and evaluation; much of the actual 'research' is performed by Navy Technical Services, which includes the Naval Dockyard, and Departments for science (collocated with NRDO), electronics, ordnance, hydrography, and communications. NRDO cited as achievements an aircraft mission planning system for use on their carrier, a simulator for the Aspide missile, a simple 'snag line' mine, a C&C system for the coastal defense 155 mm guns, a mobile test target for ASW, and an oil spill retaining boom. They are working with one of their universities on models of air turbulence over the carrier deck, and the use of natural rubber in oil

[41] My Navy host, who was responsible for aviation programs in the FMS section of JUSMAG, was also unacquainted with CINCPAC engagement resources such as APAN; this raises the question of how well the CINC's intent, and associated opportunities, have been communicated to field staff.

removal and purification. They collaborate with the Australians on ambient sea noise measurements (5 years of data from two stations near the Bight of Bangkok - I think we should be interested in this) and ionospheric soundings (7 years of data; presumably the same measurements as mentioned at MRDC), on the basis of which they have developed a predictive propagation model. NRDO had been visited by Hassan Ali, so I just briefly discussed ONR programs. They emphasized their interest in practical developments, and mentioned that their current interests were in a simple UAV for border surveillance (Dragon Eye would probably be of considerable use for CD/CT operations…is this something we may want to consider as an 'experiment'?), a 'submersible vehicle' that could carry 4-5 people at depths of 30-50M for an hour or two (not a 'submarine'…they want to move 'step by step' to start to develop some ability to work underwater; we were discouraging), a better mobile target for ASW, IT, and a capability to conduct environmental impact assessments. ONR may well be interested in their environmental issues and projects, but if so, as they said: 'we have the area, you have the technology'.

NSTDA: The National Science and Technology Development Agency is one of two such 'autonomous' (government funded but outside the civil service system and with some flexibility in use of its budget) organizations under the Ministry of Science, Technology, and Environment (MOSTE) that both fund and perform research (the other focuses more on food processing; nfi)[42]. In addition to its Hq, NSTDA has three research centers: the National Metal and Materials Technology Center (MTEC), the National Center for Genetic Engineering and Biotechnology (BIOTEC), and the National Electronics and Computer Technology Center (NECTEC). Overall, NSTDA has a staff of about 8-900, half in NECTEC. As mentioned above, its budget was 2B Baht last year, and 1.6B this year (maybe not much, but a significant portion of the total 10B of government R&D). Our host Dr. Sripainan, the Deputy Director (a S&T policy researcher who Co-directs and heads the Secretariat for the APEC Foresight Center, and the 12-person Thai S&T strategy and policy research contingent), emphasized that NSTDA and its centers not only perform in-house research, but fund competitive proposals from universities and industry; the objective is to establish cooperation among the three parties.

To improve its outreach and enhance commercial technology, NSTDA manages and is planning to move to Thailand Science Park, the country's first, located on an 80 acre site in Rangsit, 20 km north of Bangkok, between the campuses of Thammasat University and AIT. With new facilities and instrumentation for each of its centers, plus enhanced access to both public and private sector R&D organizations, NSTDA could become a strong performer in selected areas. Brochures for each of the Centers mention a wide range of projects and laboratories, and collaborations with Thai universities and SMEs (not the multinationals). In addition to R&D, they also provide information and services, including consultancy, training, and technology transfer. BIOTECH's areas of focus include plant and animal products, rural development and small-scale farmers, sustainable development, and health; they are developing medical diagnostic test kits to increase the speed of detection of common diseases. MTEC's R&D is based in part on natural resources such as rubber. They also have a core technology base in CAD and finite element analysis, and are helping suppliers to the large auto firms develop a design capability. Other work addresses agricultural machinery, and ethanol and vegetable oil as biofuels. NECTEC's new buildings will include an IC design facility. It works in electronics

[42] This is the only civilian government S&T organization I visited, and I don't pretend to understand their overall organization. Apparently there is also a new National S&T Policy Committee -- I was told the Thais' reaction to anything is to set up a committee -- that is chaired by the PM (actually a deputy) and is responsible for coordinating the various Ministries' efforts. This committee will be temporary, but a more permanent structure like it is expected when there is a new law regarding S&T; this, we were told, will take an indeterminate amount of time. There is also a Thailand Research Fund under the Office of the Prime Minister that is responsible for funding university research.

(using the internet to connect to appliances), computers (clustering PCs to substitute for large imported computers, principally to support government offices), telecommunications (wireless), and information (Thai software); it also has a policy development role in support of the National IT Committee. Once NSTDA has moved to the new facilities, it should warrant an intensive visit.

AFRIMS: AFRIMS is well known to the US tropical medical research community, so I won't describe it in any detail. It is important however to note that the Commander is Thai, and that there are separate Thai and US components; the US component has about 20 US and about 300 Thai. My interest was to better understand AFRIMS' coupling to CINC engagement efforts and EID surveillance. The command has an impressive history and extensive analytical capabilities, but could benefit greatly from more comprehensive data management and GIS systems (what they have has been developed piecemeal; a normal, but in this case very important problem given the importance of their data for epidemiology).

Most of AFRIMS' work is focused on vaccine development and testing. Their contributions in this area, as well as their help with the successful counter HIV program in Thailand, are impressive. They have started to become involved in EID (we talked to Dr Mark Lewis who has these responsibilities in addition to his work on enteric diseases), and also have a history of epidemiology and vector studies across SEA. One surveillance initiative is to start to collect better and more consistent data from Thailand's 37 military hospitals (which treat civilians as well as military personnel) -- they envision a system whose sophistication will be somewhere between that of NMRU's EWORS and those used in WR and Bethesda. There is some debate as to the balance of effort between EID and the more traditional vaccine-related mission of the unit, given resource constraints (the AFRIMS US CO favors the latter).

One apparent anomaly is that all their funds are one-year, even though they are derived (as I understand it) largely from 2-year Program 6 dollars. This makes no sense to me, particularly given the logistic difficulties and inherent delays associated with working internationally. AFRIMS could also stand some facility and IT upgrades; their buildings are jam-packed to the point of excessive use of the hallways for equipment. We didn't visit the newly renovated animal facilities, but it looked to me like the people facilities could stand the same sort of attention (it sort of reminded me of the old WRAIR). The work of AFRIMS, like that of the other US Army and Navy overseas medical labs, is appreciated by both the medical community and by the CINC. Personally, I consider AFRIMS and its sister labs invaluable. At issue in my mind is how to enhance and expand their capabilities -- in plant and animal as well as human diseases, and in environmental, genetic and sociological studies to correlate with their other surveillance and developmental research -- given the global threats of BW and EID. These labs are exceptionally important resources that are, at least in my opinion, underfunded and undervalued by their sponsors.

ADPC: The Asian Disaster Preparedness Center was founded as part of AIT in 1986, largely through the efforts of retired British Army Colonel Brian Ward, who remains its Director Emeritus. It became an independent, international foundation registered in Thailand in 1999, and is now fully multinational in scope, staff, and programs. "ADPC works with governments, NGOs and communities of the Asia and Pacific regions to strengthen their capacities in disaster preparedness, mitigation, and response through training, technical assistance, regional program management, country project demonstration, information sharing and research" (brochure). As part of their change in structure they have established a 25-nation Consultative Committee on Regional Cooperation in Disaster Management, which held its first meeting last November; the intent is to better elicit local requirements and interests, and encourage cooperative capacity development. ADPC has five primary functional areas: Training and Education (course work is conducted on AIT's excellent campus); technical services; information, research and networking;

management of regional and national activities through partners using grants; and planning, development and partner relations. They are familiar with CINCPAC resources in HA/DM, and have participated in the exercises conducted by the Trippler-based COE.

ADCP stresses local capacity and integration of mitigation measures and preparedness into indigenous planning and governing systems. Success in reducing cyclone related deaths in Bangladesh, for example, can be attributed largely to the villagers believing and responding to warnings delivered on foot and bicycle by people they know and trust. The excessive casualties from disasters like the recent flash flood in northern Thailand that killed at least 120 and displaced over 1000, may be attributed to linkages between deforestation and environmental degradation and related increases in landslides and debris flow. However solutions lie in understanding and trust of advisors, and the people being willing to listen to and heed what they are told, not just in scientific understanding of the facts. My hosts felt that efforts like GDIN focus too much on the sophisticated, top-level end of information, which ignores the need for local capacity and planning; this is a common failure of developed countries, even the UN. They also commented that GDIN was perceived as very much an initiative of the last US administration, and probably would not have much staying power. Interestingly, they were (without prompting) at least as negative to GDIN as I have been, albeit for different reasons. They did feel that militaries have much to contribute; Armies understand and practice planning and training, and also have technical expertise and mobility that can be of assistance. The Thai Army is a particularly good example because of the high regard in which it is held. Aid agencies however are reluctant to use militaries in disaster management, perhaps because they're associated with so many war-related problems that these same agencies have had to respond to.

AIT: The Asian Institute of Technology was established by SEATO in 1959. At the time postgraduate education was unavailable in Southeast Asia, so AIT was designed to fill the void, particularly in areas like infrastructure development (e.g., civil, transport, and mechanical engineering) needed by the region. As national capabilities have advanced, AIT has tried to change its programs accordingly. At present it has 1300 students (80% MS, 20% PhD) from 40 countries (including 90 from the EU which funds an exchange program), 150 faculty and 1000 support staff (largely in field areas to help with thesis work - core courses are given on AIT campuses, but most thesis work is on problems in the student's home country). One of its greatest strengths is its international nature; students get to meet their peers from throughout the region, as well as form collaborations with the international faculty. We visited the largest of its four main educational units, the School of Environment, Resources and Development (the others are the Schools of Management, Advanced Technologies, and Civil Engineering). SERD offers programs in Agricultural and Aquatic Systems and Engineering, Energy, Processing Technology, Rural Development, Gender and Resources, and Urban Environmental Engineering and Management. One program of possible interest to Navy is the new, Danish-sponsored degree course on Integrated Tropical Coastal Zone Management, headed by an American professor of aquaculture, Prof. Lin. Denmark is supporting 40 MS and 10 PhD students over 5 years; the program is of course open to others.

One major issue for the area is shrimp farming; in addition to its impact on mangroves and other coastal resources, the virus has badly hurt the industry. On the other hand, shrimp farming, if done properly, can provide a significantly better income than rice farming. One current issue is the proposed move of shrimp farming inland, behind the dikes on current rice fields. This is an emotional issue because of concerns about salinization (this concern is probably more social than scientific); however, the virus is carried by marine crustaceans and does not survive in low salinity waters, offering hope for rejuvenation of the industry without further impact on pristine coastal areas. Another major challenge is understanding the oceanographic

conditions in the 50-100m depth shelf waters where the brood shrimp live. They need modern oceanographic instrumentation and procedures to conduct these studies.

Overall, AIT can be considered one of the real successes of SEATO. It has a truly international student body and faculty, helps bind the nations of the region, and has a lot of support from not just international bodies such as the UN and EU, but from individual nations, particularly in Europe. If indeed ONR was interested in a multinational ocean-based research program in the region, AIT may be an excellent source of graduate student participation.

A.3. Thailand: Comments and suggestions

More than many of the countries I have visited, Thailand is well-covered by the US. We have a strong Embassy staff, including the EST hub (albeit in the process of rotating during my visit), and a relatively large JUSMAG contingent. There are 20 Americans in the US component of AFRIMS, and many scattered throughout industry, NGOs, and some of the universities; and most likely there are many Thai-Americans in the hospitals. While there may be no where near as many US here as in Hong Kong, they seem to be numerous and diverse in location and interests.

From the immediate standpoint of 'S&T for mutual interest', there is little if anything to attract ONR except, as one of my Thai hosts put it, 'we have the area, you have the technology'. This certainly applies to the increasingly important medical and EID research, and to any interest we may have in the littoral areas (n.b. the interest expressed at AIT in understanding the physical and biological properties of 50-100m deep coastal waters for brood shrimp). As noted in my visit reports, the military does not do what we would consider S&T, and while there may be some surprises or niches (e.g., use of natural products such as rubber or silk), the civilian research community appears likewise impoverished relative to most other countries, and likely to remain so, given the economic strategy and investment priorities of the Thaksin government. My one recommendation in this regard is that the EST section should closely follow development of the action plans called for in the July 2001 economic strategy. If something real emerges, my pessimism could be well off the mark.

There are however two aspects of engagement in Thailand that I suggest my US audience (not just ONR) consider. The first is its strength as a base for multilateral engagement. Three topics serve as examples. The first is S&T policy; albeit the Thai policy unit is nascent and small, the APEC Foresight Unit is based here (they are headed by the same man), and could serve as a multilateral mechanism for the sort of S&T strategy and policy research interaction that I have recommended in several of my earlier reports. Second, ADPC has a sound and widely respected program in disaster mitigation, as well as connections with the HA/DM COE at Trippler; militaries in general and the Thai military in particular can provide much help in a region that is highly susceptible to natural disasters, and expansion of our interactions and engagement in this topic are right in line with CINCPAC strategy. The third is perhaps the most natural and obvious, namely tropical medicine and EID. AFRIMS is an exceptional organization with a long and proud history and an extensive network of field stations. The US could, I believe, do much to improve its capabilities and expand its activities throughout the region, particularly in EID and associated environmental studies.

The second aspect of engagement that I want to recommend is not unique to Thailand, but I choose to raise it here because of the consistency of the concerns I have heard on my last several stops, as well as its relevance here: I suggest DOD consider a new form of military international engagement that is targeted at enhancing partner nations' technological capabilities in skills and systems that they believe most important. We tend to 'cooperate' (via ODC) now in two areas:

we 'sell' (FMS or direct commercial sales) weapon systems and provide training in their use (IMET), and have 'cooperative' DEAs and R&D programs, where we look for collaboration more or less as equals. There is however an in-between option, namely helping with relatively simple technology that is not in our inventory, yet above their current capacity, and below the cutting edge that we are pushing in our own advanced research. This is what most of my hosts seem to be asking for - help to help themselves, in capabilities designed for their unique situations; and it is the one thing we for some reason don't offer. I believe that doing so would do much to improve both their operational capabilities, and their interoperability with US forces. I mentioned a couple examples in my Hawaii report that were suggested by SUBPAC staff as important to improve the ability of US submarine forces to work with partner nations: basic underwater sub navigation (to help them 'stay in the box'), and simple SATCOM. In several conversations in Vietnam and here in Thailand, similar requests arose from my hosts -- e.g., simple UAVs or UUVs, affordable GIS and some help with base layer data, environmental assessment and protection technology, coastal oceanographic instrumentation, trainers, mission planning. There are literally dozens if not hundreds of topics and capabilities that fall in the cracks between selling weapons and conducting S&T as equals. Such efforts could easily be designed principally to enable them to operate better with us -- not just to give them unilateral capabilities that exceed those of their neighbors. Most importantly for the long run, they would enable us to respond to their indigenous needs, rather than -- as now -- saying sorry, either buy from us, or play as equals. The psychological and sociological differences would be immense. My sense is that such a program would be directly supportive of the CINC's engagement philosophy, relatively low cost, and even interesting from the standpoint of technological development and understanding of asymmetric capabilities, since it would help us learn how to operate with relatively low tech systems in environments with which we are now unfamiliar. It would offer a fun opportunity for US DOD lab personnel to become personally involved in 'engagement'. And it would also present a 'face' of America that is somewhat less pretentious than the 'buy my used gear' approach we now seen to adopt.

Even if we are unwilling to extend ourselves to the extent of providing technology tailored to local needs, perhaps we should at least think about recommending use of IMET training to introduce key technological capabilities. For example, the Royal Thai Supreme Command R&D unit was interested in GIS. There are excellent GIS training programs available at Ft Belvoir; has anyone suggested they use some of their IMET for this[43]? Such simple changes in our approach may indeed be an old idea, but I sure haven't seen much attention being given to helping the nations in this AOR with what they say they want, presumably therefore really need, and can effectively use, particularly for the new sorts of military operations -- SAR, HA/DM, CT/CD, peace operations, -- in which we want them to engage with each other, with us, and with their own populations. To borrow an analogy from ADPC, our reaction to medical disasters is often to fly in a plane full of brain surgeons, when what's really needed is a bar of soap. We should think about this while planning out "S&T" engagements, if indeed we are serious about supporting the CINC's strategy..

Finally, I must comment that again and again in Thailand, just like the other countries I have visited in the area, I have heard lots about support and interest from Europe -- both through the EU, and by individual nations. As the EU becomes a major competitor to the US in the west, and as the eastern large nations (especially China and India) develop economically and technologically -- and inevitably extend their influence to their near neighbors -- we are in a very

[43] I realize those courses use NIMA data, and require reasonably sophisticated software, e.g. Falcon View. But I see no major security hurdles with sharing much of this information with the folks we want to operate with in their own areas; such cooperation may even yield better info for our own maps and data bases.

poor fifth position (I threw in Australia and NZ, which are relatively quiet but influential players in the SEA game of positioning for next century dominance). As an American, I am becoming more and more concerned by our willingness to seriously reach out to other nations through our national agencies in support of our fundamental beliefs and agenda. We may now dominate commercially in terms of presence; but US multinationals are at their heart multinationals. And as a nation, all we seem to want to do is sell and produce cheaply (most folks on the country teams seem to primarily be marketing agents - and that's blatantly apparent to our hosts). It's our competitors that are making the investments in infrastructure and intellect. And in the long run, guess what wins.

B.1. Malaysia Observations

I had only one working day in Malaysia (the second that I'd planned turned out to be their National Day), and only two appointments there -- both with industrial sector R&D people -- plus a short country team discussion; then Darren Bergan drove us to Singapore, via Melaka. Nonetheless, and in spite of the less than enthusiastic perspective given by the DCM during my Embassy discussions, I was impressed by Malaysia. Very impressed, in fact. Quite a contrast to many of my recent stops.

My simplistic, 'one day, man-from-the-moon' view: Malaysia has the important basics in place (stable and relatively open government; reasonable laws and regulations, albeit some work needed from a US perspective [see the commercial guide available from www.usatrade.gov]; excellent core infrastructure[44] plus super incentives for FDI in the areas they have chosen for hi-tech manufacturing and R&D; strong but not labor-intensive agriculture; very high savings ratio (39% of GDP); good tax base; and enough quality labor with adequate education). Malaysians plan very well (more below), and they carry out their plans. Further, they seem have elected to go with what some call, in gambling theory, the "Big Bet". The theory is, once you have chosen your preferred game, and understand the rules and odds, lay your stake on one hand (or one roll of the dice, etc). For Malaysia, the 'game' is basically IT; the 'one hand' is the Multimedia Super Corridor (MSC), phase one of which is a 15x50 km greenfield development (stretching from the twin towers in Kuala Lumpur, south to the beautiful new KL International Airport) for hi-tech government, education, living, and industry -- "Malaysia's gift to the world", to quote their web page. But of course for a smart gambler, such a 'play' is not a blind play…this is where card counting, horse-sense and lots of hanging around the track, deep study, expert advice, etc. come in. And in its high-tech game, Malaysia seems to have done everything possible to get the odds in its favor. Finally, you hedge. Malaysia's 'hedge' is in several manufacturing areas (e.g.,

[44]E.g., border (Singapore) to border (Thailand) 4 lane expressway, new and beautifully landscaped, surrounded on both sides by palm and rubber plantations. You can really move goods down the west side of the Peninsula on this road. Not so of course to the agricultural and forested (tourism and agriculture) interior, or on Sarawak or Sabah, which are located on the island of Kalimantan to the SE, which is shared with Indonesia and the (oil rich) Sultanate of Brunei. For purposes of major industrial development, or R&D/S&T, the peninsula is for now the focal point. However, Malaysia is an extremely multi-cultural society (Malays, Chinese, Indians, Hill Tribes, etc.; the percentage split depends on where you are, but Malays dominate overall) and conscious of it; thus the 'technology and industry focus areas' - essential for 'critical mass' in high tech development (not to mention control of foreign acquisitions) are viewed as 'experiments' which eventually will spread to the rest of the country. I think they really mean this, largely because there is such diversity that they know that in the long run, only some large degree of equity will keep the nation's human resources together (the alternative: more Singapores). This attitude also prevails in religion. Malaysia is advertised as a major travel destination to the middle east, since almost all the food is halal. Yet Islam is moderate and tolerant here, as are Hindu and Buddhism.

automotive and aerospace, both carefully selected because of the broad utility of the associated supporting industries like composites; also pharmaceuticals based on herbs), not to mention their traditional agricultural strengths.

I'll repeat what I told our MIGHT (see below) host: "If you pull this off, in less than a decade you will have to move from 'importing' technology to leading it. Japan has faced this problem for a decade, without a lot of success. The transition comes when you can no longer find enough technology to 'transfer' from elsewhere to keep yourself ahead. That's when the hard slogging starts…you must then forge your own way into new knowledge". If the MSC works, then Malaysia needs to start thinking soon well beyond just tech transfer, more than any other SEA nation I've visited yet. If MSC doesn't work, well, then at least they should be able to survive on agriculture, tourism, and a bit of industry.

Why am I so positive on Malaysia, compared to the others I've visited in SEA? Good fundamentals, as best I can tell from my short visit; very good planning, plus commitment to execute their plans, if I can believe what they told me and the Country Team seemed to confirm (orthogonal to the Thai situation…and, with the exception of their detailed 'blueprints' for various industries which are available but for a price…their plans are immediately put on the web in English [analyzing them should be a near-term task for Darren]); and diversity, which brings a lot of different approaches to bear. The 'game' on which Malaysia has 'bet' is not radically different from those of their neighbors: IT and the knowledge society as the basis for growth, quality in manufacturing as the basis of exports, a strong domestic market, and education and R&D to support them. Malaysia just somehow seems to have its act together about all these things better than the others I have visited.

But, and it's a big but, the 'Big Bet' approach has a very obvious and ominous downside. Having pulled out of the '97 crisis better than their neighbors[45], Malaysia is now badly hit by the global, US, and Japanese slowdowns; their agricultural products, palm oil (they're #1) and rubber don't usually do well these days; they have an extension on car tariffs in the ASEAN Free Trade plan due to their stake in building their own, but have yet to develop a strong market for that car (they had a somewhat similar problem with their light aircraft); and China is rapidly becoming more attractive than SEA for many investors. So the big question is 'what's next?', and they already have their chips on the table. We were told at the Embassy that a consultancy report by McKenzie & Associates about the MSC has been 'leaked', and that the news isn't good. Progress is slow. But: their plans go to 2020. Their resources should enable them to 'gut out' a bit more of the down turn. But of course timing is everything. My sense is they made a good bet. They may ultimately prove to have been wrong, but if so you at least have to give Malaysia credit for a great try.

B.2. Malaysia Visits

MSC: "The Multimedia Super Corridor, or MSC, is the world's most comprehensive ICT development project…Much more than a technology park,…the vision…is to create the ideal multimedia environment in Malaysia to attract world class companies to use as a hub. It is a long term plan, fully supported by the Malaysian Government, that has been realistically divided into

[45] As a reminder, Malaysia did not take a World Bank or IMF loan. They restructured 'their own way'; some of the actions included freezing the Ringgit against the dollar, freezing cash outflows, consolidating the banks, and rapidly establishing a corporation to take on many of the non performing loans.

three phases[46], stretching from the year it was launched in 1996 until 2020…Two new 'intelligent' cities - Putrajaya and Cyberjaya - are already located in the MSC. Putrajaya is the nation's new ('paperless') Federal Government administrative center, while Cyberjaya, opened officially in July 1999, will become the base for many of the world's largest and most innovative multimedia companies" (brochures; see photo, also the web page of the Multimedia Development Corporation www.mdc.com.my[47]). The MDC, with the advice of its International Advisory Panel (~45 members, including Bill Gates; the IAP is chaired by the PM), has selected seven "Flagship Applications" for the MSC to accelerate the objectives of its "Vision 2020"[48]. These Applications are in two categories: "Multimedia Development" which allows partners to use the MSC as a global test bed for multimedia and IT development (Electronic Government [we visited the PM's beautiful new Headquarters in Putrajaya, see photo], a Multi-purpose Smart Card, Smart Schools, and Telemedicine), and "Multimedia Environment" which helps build excellence and innovation (R&D Clusters, World Wide Manufacturing Web, and Borderless Marketing). There are four universities in the strip, including the new, private Multimedia University, which already has 6000 students (they estimate about 35K 'knowledge employees' will be needed in the MSC).

Companies that work on the Flagship Applications and locate in the MSC can apply for "MSC Status"[49]. Companies with this status are provided a set of guarantees under Malaysian law. These include "a world class physical and information infrastructure" with wide band telecommunications and competitive tariffs, no internet censorship, "become a regional leader in intellectual property protection and cyberlaws", unrestricted employment of local and foreign knowledge workers, exemption from local ownership requirements, the right to borrow and source capital globally, competitive financial incentives (tax breaks, etc), priority for infrastructure contracts, and the assistance of MDC. These are strong inducements, particularly for companies already located in Malaysia; Boeing, for example, is moving its Malaysian Hq to the Twin Towers so it will qualify. Further, for MSC Status companies that are at least 51% Malaysian owned, the government has an MSC R&D Grant Scheme (MGS), which funds up to 70% of projects for 2 years (the MGS was allocated the initial sum of RM100M under the 7th Malaysian Plan)[50]. I have copies of MSC Status and MGS applications should anyone be interested.

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[46] Phase one is to develop the 15x50 km strip. In phase 2 it will champion and link to other cybercities globally; in phase 3 "it is expected that Malaysia will be transformed into a knowledge-based society (with a) cluster of intelligent cities linked to the information super highway, and become the platform for the International Cybercourt of Justice" - MDC web page

[47] The MDC, based in Cyberjaya, "is empowered by the Malaysian Government to champion and facilitate initiatives that will realize the MSC vision…it is the champion, facilitator and partner of companies choosing to operate in the MSC" (brochures). Basically, it markets the MSC, advises the government on MSC-specific policies and laws, and manages the programs.

[48] As noted above, Malaysia does emphasize planning. At the top of the structure is Vision 2020, the chief architect of which is Malaysia's long term PM, Dato' Seri Dr Mahathir Mohamed. Next is a 10-year Outline Perspective Plan. Then there is a series of 5-year plans. The 8th Malaysia Plan (see the web site of the National Economic Action Council) covers 2001-2005. There are also annual budgets, and sectorial plans, e.g. Knowledge Economy Master Plan. See the discussion of "blueprints" under the MIGHT visit.

[49] According to the application form, "to qualify for MSC Status and its benefits, an applicant must: Be a Provider or a Heavy User of Multimedia Products and Services, Employ a substantial number of knowledge workers, Provide technology transfer and/or contribute towards the development of the MSC or support Malaysia's k-economy initiatives, Establish a separate legal entity for the MSC qualifying multimedia business and activities, Locate in a MSC designated cybercity; and comply with environmental guidelines". Manufacturing, trading, and consulting are not eligible activities.

[50] We did not visit the Ministry of Science, Technology and Environment, but briefly discussed S&T with our host. He stated that the government is committed to S&T, and that the R&D budget is rising, from RM1B in the 7th Plan to RM1.6B in the 8th; traditionally, most of this funding was for public sector

We visited and drove around both Putrajaya and Cyberjaya ('jaya' means 'success'), and had lunch at the lovely, resort-like Cyber Lodge (who's sign proudly proclaims, "Where Paradise meets High Tech"). Putrajaya is now up and functioning around the PM's office (and near his home - a lovely large spread on a lake), with its own mosque plus housing and schools for the families of government workers who choose to live there (there are significant financial incentives for moving); most government Departments, plus amenities like shops, will move out from KL over the next few years. Cyberjaya is also functioning, and there is considerable construction going on, although not as many completed and operating facilities as I believe they would like to have at this point. However the road and utility systems are in place, the landscaping is lovely, and the light rail connecting city to KLIA is under construction.

MIGHT: The mission of the Malaysian Industry-Government Group for High Technology is "to serve the nation in shaping competency in high technology toward sustainable development" (all quotes from brochures). MIGHT is a "non-profit company limited by guarantee", a "Smart Partnership between the Government and the private sector working in synergy, prospecting primarily for business and investment opportunities for industry, policy options for the government, and research priorities for public and private sector institutions". It steered by a group of members and a Board of Directors from industry and government, jointly chaired by the PM's Science Advisor and a prominent Malaysian corporate leader. We met with MIGHT's General Manager, Mr. Mohd Yusoff Sulaiman, and members of his staff. Basically, MIGHT's task is to identify, then "mobilize and manage, joint or collective technology efforts which are beyond the resources of individual organizations"; it helps define the directions of high tech industry in the country, then serves as a 'matchmaker' or coordinator to put together the various government, industry, R&D/S&T, educational, entertainment, marketing/PR, and financial etc parties to get the business started in the direction the government desires.

Our host stated that since it was formed in 1993, MIGHT has developed 14 'blueprints" for industrial sectors or government policies[51]. They are now moving beyond sectorial analysis, to focus on the technologies themselves (e.g., advanced materials, nanotechnology), as well as associated policies and practices, such as R&D, design, and marketing (the latter being a known weakness). Their general thrust is to identify opportunities in "core technologies" where Malaysia can build capacity, learn, and develop advanced capabilities that have broad applicability, while making money. One example is the aerospace industry (the PM 'has a keen interest in anything that flies'), where they licensed a Swiss design for a light trainer aircraft and developed the associated composites manufacturing capability; they failed, however, to effectively market the aircraft and production has stopped, so that this part of the plan, at least, was not successful (I was impressed at their analysis of errors). At present, their first objective is to get their military aircraft up and flying; apparently they are grounded because of problems with the foreign avionics, and they intend to develop their own. When they move into a new area like avionics, they seek opportunities where they can 'bootstrap' local capacity - i.e., to create

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research, largely in institutions dedicated to agricultural R&D, but the increase is going to schemes like the MGS. See Chapter 13 of the 8th Malaysian Plan. Further, there are also very recent plans for a "Bio Valley" (see the MOSTE web site), which will physically overlap with the MSC (leading some to start referring to "BITS" - the Bio-IT Supercorridor), and pick up some of the agricultural research institutes. Since this idea postdates the 8th plan, it will be the subject of a supplementary budget.

[51] For aerospace, pharmaceuticals, herbal products, construction, housing, road haulage, aerospace human resource development, and low emission vehicles, advanced composites; for policies or strategies associated with venture capital, competitiveness in the knowledge economy, and national innovation systems; and directories of advanced composites and the aerospace industry.

expertise in component design and manufacturing, by initially manufacturing a needed product, something to 'link' the developing capacity to; in this case, their military aircraft[52], [53].

In space, they already have two telecommunications satellites and a microsatellite. Their next target is earth remote sensing, for which they envision a constellation of 6-8 satellites in an equatorial orbit. "Possessing its own ERS capabilities will give Malaysia control of its applications such as in monitoring natural resources, border and coastline security, and the environment[54]." Another example of MIGHT-promoted initiative is the automotive industry, where they have developed their own car brands; they are now working on the design of a 1.5l engine (jump starting an indigenous auto industry was one reason for bringing in Formula One racing). We discussed other automotive opportunities (like a car people can fix themselves), based on their focus on low emissions and fitting the vehicle to the environment.

We also talked for some time about shipbuilding. Malaysia has a shipyard (apparently associated with their Navy - the Attaché was quite familiar with it and their naval ship building and acquisition plans), and a marine engineering faculty with some hydro test facilities at the University of Technology of Malaysia in Johor Bahru, which is just across the border from Singapore (we will try to visit; if we miss, it's high on Darren's list; it will hold a Marine Technology Seminar on 30-31 October). They are particularly interested in a SWATH vessel, either for oceanography or for the Navy, but realize that they are starting from zero. I noted that while there are a number of research vessels in SEA, none are purpose-designed for modern ocean science; and I volunteered to recommend some people they could talk to, to get a better feeling for requirements and design alternatives. Darren will follow up.

B.3. Malaysia Comments and Suggestions

I was told we have very good military relationships with Malaysia. Good industrtial relations also, since we're a major trading partner (our 11th largest; and our 17th biggest export market) and the heaviest in FDI (oil & gas, and manufacturing, especially semiconductors and electronic components). As someone on the country team said, what's good for Malaysia is good for the US. Despite the less than enthusiastic picture painted by the DCM (and the economic downturn of late), the Country Commercial Guide (as of 15 July) is distinctly upbeat. And, official relations with the US have become significantly more friendly since the Bush administration took over (recall VP Gore's rather disparaging speech here a few years ago).

On the negative side for ONR, this is a hot spot for industry, not S&T. For now, that is - see my Observations. What there are in the way of government research institutes, are largely focused on

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[52] We were accompanied by the US ODC FMS officer, who kept trying to interest them in buying some of our E2Cs or similar equipment. They were polite, but made it very clear that this type of acquisition held absolutely no interest to MIGHT, indeed was counter to their objectives; albeit they would defer to the MOD in military procurements. MOD incidentally has an S&T Centre and several Divisions which may be of interest to us. There is also a Malaysian Defence Industry Council (see http://mdic.mod.gov.my)

[53] An article entitled "Smart Partnership in the Aerospace Industry" in the MIGHT Journal FUSION, No 3, Jan 01 - authored by our host Mohd Yusuff Sulaiman - discusses the global nature of the industry, and the coupling between military and civilian interests. Malaysian initiatives will include R&D (as a priority area), "buy some" of strategic technologies, encouragement of higher value added activities along the value chain, offsets, and partnerships. I'm told the Malaysian company AIROD already does a significant amount of maintenance, including depot level maintenance of US C130's.

[54] "National Space Program", ibid. We discussed ERS data; one of their problems is that Malaysia is composed of 13 'States'. Each has power over land matters, and they fight centralization. Thus the country has no fully digitized national geospatial data base. For more information, see the Malaysian Centre for Remote Sensing (MACRES), and the National Land Information System (NALIS).

agriculture. Education is predominantly undergraduate (the Commercial guide lists education as an investment opportunity, for good universities - Europe and Australia are in the market). The overseas companies that have been here for some time have apparently trained and educated a lot of their employees, but they recycle those resources in their own facilities, in Malaysia and abroad.

On the other hand, the Malaysian ODC would very much appreciate help from our IFO branch in Singapore. Nb. my footnote #17, on the attitude of MIGHT to FMS. R&D plays heavily in Malysia's plans, even if S&T may not. And with all the industrial investment, and their press for local capacity, we need to stay attuned. Also, as opposed to Thailand where there is an EST hub, here EST responsibilities are given to an FSO coming from, or going into, consular duties. These are bright junior people, but without the experience and breadth of familiarity with US agency interests that promote ready access to what we might like to know. However, we were told that DOS is sponsoring an NSF scientist to visit Malaysia for 6-8 weeks, and he (Dr Fisher?) was arriving just as I left. He will inevitably gain much more insight than could I, and Darren should visit him.

Thus for now, my suggestions regarding Malaysia are all for actions by Darren Bergan, should the IFO agree that his venue should extend beyond the confines of Singapore:
- acquire, read, and report on all the planning documents that may influence Malaysia's R&D investment strategy (some were discussed here - they should all be on the web, or otherwise available in English)
- visit the University in Johor Bahru, and follow up on our discussion at MIGHT of possibilities for future SWATH ship construction. We should try to couple Malaysian scientists with our university oceanographic community.
- Visit and report on MOSTE, MDIC, and the MinDef S&T Centre
- Offer support to the Malaysia Country Team to augment the ODC program via DCA and S&T activities, and explain to them the significant differences among them (Darren understands this).
- Visit with the NSF rep near the end of his time in country
- visit the Malaysian anti-piracy C&C center, and the IMB Piracy Reporting Centre in KL

Itinerary and Contacts
Thailand
23 August, Thursday: Arrive Bangkok 1540; host CDR Brian Rinaldi, JUSMAG-Thai.
RON JW Marriott, Sukhumvit
24 August, Friday: AM: CC DCM Huso; Country Team discussion
PM: Military Research and Development Command, Supreme Command;
MG Weera Phlawadana, RTA & 8 senior officers
25 August, Saturday: Ayuthaya, Bang Sai, Bang Pa-in; 39th Anniversary
26 August, Sunday: Dr Edsall departs; Bangkok area
27 August, Monday: AM: Naval R&D Office; RADM Tana Banang & Staff
PM: Armed Forces Research Institute of Medical Science, US Component:
Col G.D.Shanks, MD, Commander; Maj. M.D.Lewis, MD, MPH (Enteric Diseases, EID) AFRIMS contact phones: 66-2 644-6691/6125
28 August, Tuesday: Host: Kanchana Aksorn-Aree, Economic Spec't (Env'l Affairs), kanchana@state-gov
AM: (1) Asia Disaster Preparedness Center (ADPC): www.adpc.ait.ac.th
Brian Ward, Director Emeritus (adpccons@ait.ac.th, 66-2 524-5354-9 x103)
David Hollister, Dep. Exec. Dir. (daveholl@ait.ac.th, 66-2 524-5381)
Gaurav Ray, Project Dev't Coord'r (guravray@ait.ac.th)

AM: (2) Asian Institute of Technology, School of Env't, Resources & Dev't www.serd.ait.ac.th
Prof Chongrak Polpraset, Dean (chongrak@ait.ac.th, 66-2 524-6074)
Prof C. Kwei Lin (Aquaculture), Coord'r, Integrated Coastal Zone Management (lin@ait.ac.th, 66-2 524-6200)
PM: National Science and Technology Development Agency (www.nstda.or.th)
VP: Chatri Sripainan (chatri@nsda.or.th) Also: Co-Dir, APEC Center for Technology Foresight; and Head of Thailand's S&T Policy Research Unit

29 August, Wednesday: Transit to Malaysia

Malaysia

29 August, Wednesday. Arrive Kuala Lumpur ~1510; hosts Darren Bergan & Maj.Douglas Dawson USAF. RON Regent Hotel

30 August, Thursday: AM(1): Multimedia Super Corridor Research Department, Manager Technology Policy & Research, Mr. Paramjit Singh Tyndall (8311-2179)
AM(2) & lunch: Malaysian Industry-Government Group for High Technology; General Manager Mohd Yussof Sulaiman (yussof@might.org.my, 603-8888 1831)[55]; Principal Analyst Asmadi Md. Said, asmadi@might.org.my, -1888); Tech'y & Industry Development Division, Shirley Selvaraj (Shirley@might.org.my. -1820)
PM: Country Team short brief, DCM Robert Reis & staff; Evening: National Day street party

31 August, Friday: Malaysia's National day. Drive to Singapore via Melaka.

Above: Construction in Cyberjaya Below: PM's office in Putrajaya

[55] Office of the Science Advisor, Prime Minister's Department, Level 2, Block A3 (West Wing), Federal Government Administrative Center, 62502, Putrajaya, Mayalsia

Report 7: 1-11 September 2001: Malaysia Update, APEC, Singapore, India
A. Malaysia Update
B. APEC - a short note
C. Singapore Observations and Visits
D. India
E. Comments and suggestions: Singapore, India

NB, 9/13: Most of this was written prior to the recent terrorist attacks. I was drafting the India section during the events, and have finished the report after my arrival in Australia. Given the unknowns of the future strategic situation and international relationships, I have elected to simply press on with this report, on the basis of prior assumptions. I recognize that much of this may be OBE. CED.

A. Malaysia Update

While I have not changed my opinions regarding Malaysia, there are three additional points that I want to mention, based on subsequent events and discussions. First, there is considerable concern here in Singapore (3 Sept) over the possible rise of Muslim fundamentalism in the region. While this would most likely start in Indonesia it might spread in some form to Malaysia; and there is even discussion in the papers about a still very low level movement to carve an Islamic state out of some combination of the Philippines, Indonesia, and Malaysia. Such sentiments would be most appealing if the region has prolonged, severe economic problems, or increasing instability. Second, and potentially countering any such divisive trends, is the recent resurgence of local interest in ASEAN as a powerful regional collaborative mechanism. The leaders of Indonesia, Philippines and Thailand have all been actively traveling throughout ASEAN, and their discussions with each other and the other leaders, perhaps spurred by concerns over the possibility that China could attract away much if not most foreign investment, have led to re-emphasis on the importance of making the 10-nation ASEAN grouping both a significant integrated market area, and a desirable locale with diverse opportunities for FDI. Either or both of these contrasting dynamics could influence Malaysia's plans for the development of the MSC.

Third, and of most immediate local importance, Singapore Senior Minister Lee Kuan Yew has just concluded a visit in KL with Malaysian PM Dr Mahathir Mohamed, during which they reached agreement on several long term, 'sticky' issues between the two nations. These include Malaysian provision of water to Singapore (to beyond 2060; and an associated price), train and road infrastructure between the two nations, and Singapore AF access to Malaysian air space. Although details remain to be ironed out, the two leaders in a very short period of time made a 'deal' that removed many of the most significant points of friction between the two. Although local discussion centers on who got the best of the deal, and 'why now?', improved relations between these two powerful neighbors augers well for the economic development of both (Malaysia is Singapore's #1 trading partner), greater confidence by potential foreign investors, and the opportunities for ASEAN as a whole.

One reason that I raise these points, is that I am beginning to believe that ASEAN is a logical focal point for our own S&T interests, and an appropriate scope of concern for the Singapore office. Of course ASEAN has a very diverse mix of advanced to almost totally undeveloped nations, but if enhanced multilateralism is in our strategic interest, and if Vietnam and others are to be US S&T partners, then it's the obvious right place to start in this region. The ASEAN nations at a bare minimum share a common economic competitor (north Asia), similar climate, control of some very strategic waterways, and diversity of ethnic and religious groups; as well as

the heralded ASEAN free trade region that should soon start to have a real effect, if the current dynamics among the local leaders can be parlayed into a more solid commitment to regional cooperation[56]. Further, ASEAN in my mind is a good 'lab' for experimenting with the sort of DOD/Service/DOS collaborations that I envision as the proper direction of evolution for IFO activities overall.

B. APEC - a short note

We visited the Asia-Pacific Economic Cooperation (APEC) Secretariat, which "comprises 23 officials seconded by member economies" (brochure) plus local support staff. "The Secretariat is the core support mechanism for the APEC process", performs advisory and public affairs functions, and supports the APEC Sectorial Ministerial Meetings, APEC Committees, and 11 working groups. APEC is of interest in the context of this report because is it a mechanism for multilateral studies and planning, and has interests that include S&T and oceans. In particular, the Industrial Science and Technology Working Group is holding the '1st APEC S&T Policy Forum' in Malaysia on 8-9 October, in conjunction with its 21st ISTWG meeting. The theme is "Science, Technology, and Innovation in the New Economy: Building Capacity Across APEC", and there will be discussion on four topics: developing S&T networks, roadmapping, human capacity building, and connecting research and innovation. I have suggested in several reports that S&T strategy and policy is a topic we should pursue in greater depth, and this forum would offer a good opportunity to meet many of the interested parties. There is also a Marine Resources Conservation group, that includes among its activities the development of an "Ocean Models and Information System for the APEC Region" (OMISAR). In general, we were told, the web pages of APEC and its working groups are good places both for information and to raise issues and suggestions. Our APEC hosts also suggested that we contact the Pacific Economic Cooperation Council (PECC), whose secretariat also is in Singapore; PECC is a 'feeder' group to APEC for academic input on S&T and related economic issues.

C. Singapore Observations and Visits

There have been many senior ONR visitors to Singapore[57], and Darren Bergan and his colleague LCDR Ross Sawtelle accompanied me at all my meetings and have copies of cards and material, so I will not bother with any details of meetings or contacts. Indeed Singapore is if anything even better known to us than Japan, with some 1200 US companies and 18K Americans, notable transparency, and very active economic, EST, and commercial sections of the Embassy, in a small[58] English-speaking area that has only relatively few, closely connected research universities and institutes. The dominant activities here are international industry and trade; and the recent surge in military interest (Darren notes that the level of activity has multiplied four-fold since he arrived) is founded largely upon Singapore's program of ensuring that many large nations, not least the US, feel that they have a strategic stake in Singapore. As our Naval Attaché put it, they want to be viewed as a friendly country with a thriving economy and a carrier at the pier.

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[56] We were told, however, that Singapore is frustrated with the slow speed with which ASEAN nations are approaching the free trade agreement, and is negotiating agreements with the US and other western nations to produce a 'demonstration' effect.

[57] Indeed some hosts wondered why they were being besieged by yet another…

[58] 627 mi^2; dependent upon Malaysia for much of its water; an excellent deep water port; superb infrastructure, and -- like Hong Kong -- mostly 'vertical' housing to preserve as much green space as possible

From the perspective of economic development, Singapore's 'four pillars' are electronics, communications technologies, chemicals (largely oil and gas based), and biomedicine (the newest addition). From a security standpoint, their strategy is dominated by their location and size; they are an island country with limited manpower[59] and no physical buffer zones, indeed little room to train. Thus their priorities are deterrence via early warning, and a powerful rapid reaction capability; and their R&D focus is on ISR, 'virtual' training, and robotics, plus M&S to help them make decisions about what and where to buy. Both their economic and security strategies therefore impel them to invest heavily in S&T and human resource development; and commensurate with their philosophy of 'many friends' and globalization (we were told that this has been a strategic imperative at the National University of Singapore (NUS) for the past 5 years, for example), they openly solicit researchers and technology from everywhere, and have developed an excellent ability to merge or integrate ideas and components from many sources. I envy their lack of the NIH syndrome.

From the perspective of opportunities for S&T cooperation, we are primarily interested in the activities and policies of the Ministries of Education, Trade and Industry, and Defence. These are all well coordinated. Singapore has had a stable, essentially one-party government, dominated by the policies of SM Lee Kuan Yew, since it became independent in 1965. Stability is perceived as the cornerstone of economic prosperity, and limitations on certain freedoms are the accepted price. Concomitants to this type of system are careful planning and coordinated execution; further, given their size and situation, national security and economic considerations are inextricably intertwined, indeed almost matrixed, both in planning and in execution. Thus although it is somewhat easier to describe civilian and defence S&T sectors separately, people move back and forth (and go in and out of the military, sometimes in the same job, during their annual service commitments) and the institutions are very closely connected (witness the formation of MinDef's Temasek[60] Institute at NUS to coordinate all MinDef R&D at the University as well as develop its own expertise, and the plans for a similar institute at Nanyang Technological University [NTU]).

The Ministry of Education receives the lion's share of the national budget. Singapore is noted for the quality of its education (and parental concern)[61], and the children are tested several times as they progress through school, the results determining their placement in the University system (they are free to select which University or Poly they will apply to, but ranking ultimately determines where they go and what course they enter). Like in Hong Kong, the government regulates University size based on beliefs about how many secondary graduates can profit from tertiary education[62]. About 20% go on to University (increasing to 25%; there are 3 Universities

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[59] Singapore has universal male conscription and a requirement to serve for a few weeks annually for many years following the 2-2½year active duty period.

[60] Temasek is the ancient Malay name for Singapore; it translates as 'water village'. This is a 'reserved' name, meaning that companies and shops can not use it for commercial purposes. The implication is that the Institute has a strategic national purpose.

[61] Albeit much of the primary and secondary schooling, I am told, is based on rote learning, and the students are not encouraged to ask questions, lest they seem disrespectful. I'd expect that under western, especially US influence, much of this is changing, and that inquisitiveness and problem solving are beginning to be stressed. This is one reason they want to hire western faculty. Still, much of the educational process is likely to be devoted to 'skill development', given their industrial needs as well as the Chinese heritage.

[62] Another similarity is that most graduates want to go directly into business and make money, so that a significant proportion of the postgraduate students are international. One drastic difference is that Hong Kong limits the number of international undergraduate students to <4%; Singapore is shooting for

[we visited two, NUS and NTU], with a fourth planned), and another 30% or so to Polytechnics (4 now, a fifth planned, ahead of the new University; there are also lesser degrees of technical training, and 'continuing education' and training designed to refresh skills -- Singapore believes strongly in manpower development[63] at all levels, since much of its industry is based upon skill and quality as opposed to cheap labor). Universities receive about 80% of their funds directly from MinEd; this covers salaries, most infrastructure, funding for small projects (up to S$500K) that is apportioned by the school, 'research scholarships', and large project funding that is competitively evaluated at the national level. The rest of their funds come from the National Science and Technology Board (NSTB) of the Ministry of Trade and Industry (MTI), other Ministries such as MinDef, or from industry. From everything we saw there is no lack of resources; first rate equipment, many new buildings, much construction, lots of plans for more.

We visited the two major science and engineering research universities, NUS (founded 1905), and the 20-year old NTU. Their rivalry seems, on the whole, healthy; and while there is some inevitable overlap, there are deliberately separate specializations. NUS has about 22K undergraduates and 8600 postgraduates; it developed along British lines (e.g., undergraduate medical [5 years study plus 1 of practice] and law degrees), but is moving toward a North American type system (e.g., adding pre-med undergraduate course). NTU is somewhat more American in style, and has 16K undergrads and about 5K graduates. It was constructing a new dedicated research facility to house major multidisciplinary projects, when we visited.

Both NTU and NUS have missions that include education, research, and global outreach in support of the nation's development. Both recruit internationally for students and faculty. And, both have a number of Research Institutes or Centers, at the National (sponsored by NSTB), University, and Faculty/School level. We visited several engineering labs and centers[64], and all were impressive, with top rate international researchers, lots of bright active students, and the best, newest equipment money can buy[65]. If in general they are not quite 'world class' yet, they are sure giving it a good shot, are on a steep curve of improvement, and have niche capabilities that should surely be of interest. Of particular note are the quality and intensity of international collaboration. For example both universities participate in the jointly taught Singapore-MIT Alliance (SMA), and John Hopkins has a significant joint medical program. They briefed us on a wide range of opportunities for Singapore students to study abroad and vice versa. Perhaps most noteworthy is a new scholarship program for scientific and engineering PhDs open to any student anywhere to go to any of a select list of international schools, provided that they agree to work in Singapore for 5 years after graduation. In sum, MinEd and the Universities have a truly

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something on the order of 20%, and has numerous programs to send its locals overseas for part of their education. They view economic dominance as requiring a truly global perspective which can only be gained by international experience, imported or exported.

[63] With perhaps an emphasis on the 'man'. Only at DMRI did we encounter any women academics or administrators. Women may be important in society and the home, perhaps even in business, but gender equality as we would view it does not seem to pertain in science and engineering

[64] Robotics, optical sensors for structural testing, and signal processing at NTU; MMIC and the compact EM test range at NUS. We also visited the 2-year old Tropical Marine Studies Institute (10 faculty and ~50 soft money research staff) at NUS and heard about its work in acoustics and oceanography. Some of their people participated in ASIAEX. I believe they would make a good partner for additional research in the region; they have a NICOP proposal related to mine burial.

[65] The principal limitation seems to be US export controls. We heard several comments about holdups and other difficulties. We were told at the Embassy that while Singapore has good controls on goods entering the country, it has practically none on goods in transit, since they want to minimize burdens in trade. It is again interesting to compare Hong Kong which has strong export controls.

impressive effort to build quality and globalize, and a strong base from which to improve. They are far ahead of any of their neighbors, indeed in a different class altogether.

The second Ministry of interest is MTI, notably its National Science and Technology Board (the provenance of NSTB says a lot about its focus and objectives), and its sister organization the Economic Development Board (EDB). They were established in 1991, to implement plans to raise the level of S&T in Singapore. The first 'National Technology Plan' (91-95) had an allocation of S$2B, the 'National S&T Plan' (96-00) S$4B, and the current 'National S&T 2005' Plan has a 5 year budget of S$7B[66]. Of this, NTSB has $5B for public sector R&D and manpower development, and EDB has $2B to encourage the private sector to set up R&D labs in Singapore.

The mission of NSTB is "to encourage, develop and nurture human capital in scientific and engineering research and indigenous capability development for a knowledge-based economy in Singapore". It is organized into two research councils, the Science and Engineering Research Council (SERC; with sections for Electronics and Manufacturing Technology, Information and Communication Technology, and Chemicals and Other Science), and -- befitting the new emphasis on life science and human health -- a Biomedical Research Council (BMRC; with Sections for Healthcare and Clinical Research, Cell and Systems Research, and Training and Career Development)[67]. Both have technology transfer offices. Together, these councils oversee and support the research funding of 16 Research Institutes and Centers[68], most of which are located at and have joint staff appointments with one of the Universities. Programs are not competitive (yet); each institute prepares an annual core proposal that when approved by the Council and NSTB goes to MTI and Ministry of Finance for approval. Overall there are about 7K people in the research institutes, of which ~15% are international (including permanent residents). Included in their plans, again because of the new emphasis on life science, is a new "Biopolis" where NSTB will move, and consolidate biomedical research, by 2005 or '06[69].

MinDef, like MTI, has a large R&D structure[70]; and as with the civilian side, I got to visit both the oversight/funding agency, in this case the Defense Science and Technology Agency, 'a statutory board legislated by act of parliament' (meaning non civil service but still authorized to

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[66] Overall, GERD/GDP = 1.84%, going to 2%. As I understand it, this does not include Education funds.

[67] There is also a Policy and Admin Division. NSTB publishes a National Survey of R&D (we got the '99 edition) , which tracks a number of statistics and indictors. Foresight studies, and presumably other S&T strategy and policy studies, are conducted by a recently corporatized entity, ARCHON. We were told that some of the other Research Institutes also either are, or will be, made private entities; staffs of the rest, like University faculties, are government employees. They recognize the restrictions this entails..

[68] Environmental Technology Institute; Institute of Materials Research and Engineering; Centre for Signal Processing; Data Storage Institute; Institute of High Performance Computing; Institute of Microelectronics; Centre for Remote Imaging, Sensing and Processing; Centre for Wireless Communications; Kent Ridge Digital Labs; Bioprocessing Technology Centre; Institute of Molecular Agrobiology; Institute of Molecular and Cell Biology; Gintic Institute on Manufacturing Technology; and three new ones this year, a Genomics Institute, Bioinformatics Institute, and Institute for Chemical Science.

[69] There are already two Science Parks, as well as a number of Technology Parks, and associated housing and eating accommodations. These are operated by Ascendas, "Asia's leading developer, manager and marketer of science, business and industrial parks, with a S$1.2 billion property portfolio in Singapore, India, China and the Philippines" (brochure). Ascendas Pte Ltd is in turn a full-owned subsidiary of JTC corporation, "Singapore's pre-eminent industrial property group."

[70] I wouldn't doubt that the other mission-ministries do also; e.g., Ministry of Environment. Worth looking.

act on behalf of MinDef)[71], and some of its performers[72]: DSO National Laboratories (formerly the Defense Science Organization, but made a not for profit 'company' in '97 to give it better operational efficiency and commercial practices; DSTA thus treats it as an 'affiliate'), the new Temasek Labs at NUS, and the Defence Medical Research Institute, also at NUS (Temasek and DMRI both will get their own new facilities within the next few years).

DSTA aims to "meet SAF's increasing technological needs without further straining limited national scientific and engineering manpower resources" (briefing slides). This in itself says most of what needs to be said about the close coupling between economic and security related R&D. Singapore allocates up to 6% (historically it's been closer to 4-5% of GDP) for Defence; of this, 4% is in R&D, ~S$300M/year[73]. DSTA does much more than R&D - indeed its R&D Division is less than 25 people out of over 2700 in the Agency[74]; overall it is responsible for procurement (everything but simple supplies), information systems, base camps, hardened facilities, advice, and promotion. Their approach is buy what they can, upgrading where cost effective; tap external resources where possible (tech transfer, from international and commercial sources); build local defence industry in strategic areas[75]; and do R&D for their own special requirements.

We talked for some time about international collaboration, and in particular the increase of activity with the US. We were told that it was DepSec Peter Ho's personal agenda to increase activity with the US, and that USD(A&T) Gansler was receptive. Prior to the Clinton administration they had perceived that the doors were closed, and had sought partnerships where they believed they could establish equity, e.g. with Sweden. Now however they are considering both top down (e.g., NEMO, LALEE[76] - both focused on increasing warning time) and bottom-up, researcher-inspired interactions. These shifts have helped considerably to 'open up' DSO and the other Institutes intellectually, all in line with their recognition that they don't have enough internal resources to meet the breadth of their S&T needs. As noted above, Darren's load has quadrupled in just over a year, the counterpart Singapore R&D staff in DC has grown from one person to four, and Army and AF have both established SNR relationships (or soon will). The Services on both sides, as well as the Ministry, are now engaged.

DSO has an annual revenue of about S$250-300M, including contracts, and a staff of about 700. It is headquartered in one of the Science Parks. It gets 31% of its work directly from

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[71] There is also a Defence Technology and Resources Office in MinDef, that reports to the Deputy Secretary for Technology. While DSTA is an important link, DTRO - like our own DDR&E - should be an important place to visit to help understand strategy and investment policies.

[72] In addition to the ones I visited, DSTA also has CSO (C4I) and SCO. I am not aware of anyone from the US who has visited these. They should be on Darren's list.

[73] This is for local capability…i.e., it doesn't count the R&D commitments and payments for foreign procurements, such as US FMS or the French stealth frigate.

[74] As opposed to Universities and civil organizations, DSTA, DSO and other MinDef organizations have restrictions on foreign employment.

[75] I asked for explication. They said this basically means, first, operational support, i.e. the ability to maintain anything they operate. Second, transition from DSO into the field. The prototypical example is land armored vehicles; terrain is 'neutral' for ships and aircraft, but there are unique requirements imposed by their land geography (e.g., water transit; spacing of rubber and palm trees on plantations).

[76] LALEE (Low Altitude Long Enduring Endurance [?]) is an indigenous UAV designed to provide continuous surveillance coverage over Singapore. It has a 4K# changeable payload, and about 12 hour endurance. Initially it will be manned to facilitate FAA approval. They are also developing sensors for it; e.g., a SAR; we saw the x-band MMIC arrays at NUS. There is apparently some US interest in this vehicle.

DSTA/MinDef, 21% from the Joint Staff, 13% each from Army and Air Force, 20% from Navy, and 2% non-defense. While most of this work is project-specific, if has two 'degrees of freedom': Technology Development Programs, block funded, where DSO gets to determine the specific projects; and about S$10M of 'lab directed' research[77]. All of its work is what we would call applied research and advanced technology. DSO has 13 Centres[78], and we received a brief description of the work of each. They have collaborative agreements with Sweden, the UK, France, Israel and Australia as well as the US. The UW center, which they featured, focuses on sonar signal processing for ASW, MCM, and environmental acoustics (and includes a 3 year program on Synthetic Aperture Sonar). For a brand new group, their work seemed quite impressive. Apparently they have an ASW workshop at NUWC planned for next summer.

Since DSO, CSO and SCO do applied work, most basic (and early applied) defence related research is conducted at the Universities; and given its age and stature, much of this is concentrated at NUS[79]. MinDef therefore decided to establish Temasek Labs as a '3rd pillar' (with the other labs, and industry) to coordinate all their programs at the University, and do the 'more upstream' research in selected new areas 'critical to Singapore's defence and security'. This also enables them to be more 'open' in the basic elements of their research, to involve students and help train scientists and engineers, and to emphasize international collaboration (e.g., a DSTA-NUS-Supélec-ONERA cooperative program in Aerospace engineering, headquartered in Paris). Temasek Labs is building up a number of Programmes, starting around a core in EM (antenna design, propagation and scattering) and aerodynamics (flow control, computational fluid dynamics, design). Additional areas of specialization will include information security, signal processing, non-linear dynamics, and meteorology (the Director, Dr Lim, Hock is himself a meteorologist, and came to Temasek from the National Centre for Remote Imaging, Sensing and Processing, which he also started). Temasek expects to have a staff of 35 by late this year, 80 by the end of '02, and ultimately a total of about 250. It will have its own new, 20k m^2 facility on the NUS campus by '03 or '04. Also, as noted above, there will be a similar lab at NTU.

DMRI is the SAF's lab for medical and human factors research. It expects to benefit greatly from the new national initiative in life sciences. It has 75 staff including 16 PhDs, and a budget of S$7M; this will grow to S$36M by '05[80]. It is headed by a retired BG who until recently also headed their military medical command. DMRI has programmes in infectious diseases (biochips for rapid detection and field use), the genetics of human diseases (they are particularly concerned with myopia and heat stress), advanced drug delivery, combat care, optimal performance under extreme environments (heat, high g, ergogenic aids, sleep cycles), human modeling, human factors engineering, and visual performance (management of myopia, eye protection). We visited

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[77] This is funded first from any accumulated surplus (recall DSO is now a private company, although we officially treat it as a government entity for purposes of defence cooperation in armaments), supplemented if necessary by DSTA.

[78] Advanced Electronics and Signal Processing; Chemical Defence; Decision Support; Electromagnetics; Information Systems Security; Physical Sciences; Advanced Systems; Communications Systems; EW systems; Radar Systems; System Engineering; Unmanned Systems; and a new Centre for Underwater Systems, headed by Dr Gooh, Joo Thiam, a PhD student of Heinrich Schmidt at MIT.

[79] Examples include the Lab for Radar and Signal Processing; the Physical Oceanography and Applied Research Labs at TMSI, parts of the IHPC, an EM compact range, a new Center for EMI/EMC, and the S$30M Mach .25-4 transonic wind tunnel, being purchased from the US (transonic portions pending export license). NUS is also the host of the Defense Technology Systems Course that all mid-grade officers must attend, and the Singapore partner for the new Temasek Defence Systems Institute, taught jointly with NPS.

[80] Growth numbers like this have already been approved; as opposed to the US, once such a decision is made, it is not subject to yearly perturbations, barring very major problems.

the well equipped Biological Sciences lab which has 30 staff, and saw some of their work on both bacteria (e.g., melioidosis is endemic) and viruses. They collaborate with NMRU and AFRIMS, so I expect that their work and capabilities are well known to US researchers.

Overall, my assessment is that Singapore has a well developed educational and S&T infrastructure, and both the money and the will to make it world class. The various elements seem well integrated, and there are few structural barriers to improvement. As much as anywhere else I have been, including Japan, they recognize that economic success in a 'knowledge-based' economy will depend heavily upon their ability to move rapidly and exploit new ideas, meaning a good R&D capability in industry as well as the universities and institutes. At issue is their ability to 'import and export' the global interconnections they need to build the peer interaction and intellectual competitiveness incentives needed to become world class. They may be at the center of South East Asia, but that's still a heck of a long way from the intellectual core of North America, Europe, and even North Asia; and they are still small and insular. They have succeeded since independence in developing wealth by attracting and supporting international commerce. The question is whether they can pull off the same trick with the international R&D capabilities they believe will be needed to maintain their momentum, and capture a significant share of the action in the next generations of electronics, IT, BT, and chemicals on which they are focusing. In the interim, they are sparing no effort to build top notch capabilities in their selected areas, and if they aren't yet there, they are certainly headed in the right direction, and are a crossroads for ideas and technology from around the globe. For those reasons if no others they are worthy partners for international S&T collaboration (and ranked highly by our competitors).

D. India

This visit differed from my others in that my major objective was to accompany and help Maj White and Mr. Bergan evaluate opportunities for reinitiating mil-mil R&D interactions and DCA cooperation with India (an issue which will be discussed with CINCPAC J4 and DOS) once the sanctions are lifted (expected to be soon; the new US Ambassador is clearly and publicly stating that his mission is to transform the relationship between India and the US). This involved explaining ONR's interests and organization and the nature of our office in Singapore[81]; discussing the types of cooperation available under the various DCA programs; and attempting to elicit from our Indian hosts, areas in which they would be interested in cooperation. Thus all of my formal Indian contacts were MOD or Navy. I also however had an opportunity to discuss Indian S&T and the Indo-US S&T Forum with Dr DiCapua, and -- at the dinner kindly hosted by the DCM -- with Dr Arun P. Kulshreshtha, Advisor and Head, International Division, Ministry of S&T, Department of S&T. Rather than describing each visit, I will attempt to summarize the main points pertinent to the issue of future US-India Defence S&T relationships.

First, collaboration in naval matters and R&D is more likely to be of more mutual US-India interest as an initial engagement area, than aerospace or land warfare. This is due both to India's strategic situation and ongoing security interests (e.g., it is more likely that we share interest in SLOC protection in the IO, and anti-piracy, than in disputes in the Kashmir), and to the long history of S&T interaction between ONR and Indian scientific institutions and universities. The efforts of Bhakta Rath and Bernie Zahuranec have not gone unnoticed. This is not simply my

[81] Darren's responsibilities as DCA officer in the Embassy couple him to all Services and the country team, especially the EST officer, as well as to the IFO. As discussed under my recommendations, this is a model for the sort of coupled civil/military, S&T interactions that I believe are not only appropriate for India, but should be emulated in one organizational form or another in other countries.

own conclusion, but also the opinion of both Maj White (USA) and the Naval Attaché, and I believe also of the DCM.

Second, if we want to start engagement by capitalizing on ongoing projects, it is important to define opportunities with the Indian military labs (and the scientists they fund in universities) that couple with research started under the Rupee Fund. Our hosts seemed to agree with my contention that cooperation in other more 'advanced' aspects of system and doctrine development work best when they are underpinned by a common understanding of S&T opportunities, and collaboration in basic research. From the US perspective, this approach would maintain continuity of our long term interests, and ensure that new mil-mil activities were correlated with our efforts under the Indo-US S&T Forum. Perhaps more importantly, it would enhance civil-military S&T coordination on the Indian side (most of my contacts were not initially aware of the Forum and its objectives).

Third, as we move toward more in-depth engagement, it will be important to improve our understanding of evolving Indian maritime strategy and its likely impact on force structure, and to be sensitive to actions which might counter or pose obstacles to collaboration. On the first point, we were told that in absence of an accepted major national strategic role, India's Navy is 'balanced' -- basically, some of everything. This strains them, particularly in view of the 22:2:1 ratio of Army:AF:Navy; but it also makes the Navy proud of what they have been able to accomplish with limited resources. Maritime interests are now under discussion, and India is evolving a strategy of naval support of land actions (warfare, but also disaster mitigation and response; thus an interest in landing craft), and assurance of safety of the SLOCs from the Horn of Africa and Straits of Hormuz, to the Straits of Malacca. This area includes their own strategic straits through the Andaman and Nicobar Islands, and associated anti-piracy actions[82]. On the second point, the Indian VCNO was pointedly upset about the recent military surveys by USNS BOWDITCH. He thoroughly understands the difference between oceanographic research and military survey, and the importance of freedom of navigation, but was equally adamant that collaboration and joint efforts could produce similar or better results in the EEZs and waters of strategic importance to nations with whom we wanted to develop improved cooperation. We agreed to mention his concerns. My point here is simply that our signals, particularly at this juncture, should be consistent. It makes no sense to simultaneously insult and woo them.

We talked about possible areas for collaboration, and about the organization and objectives of the US parties that might participate (especially ONR, NAVSEA, and the Warfare Centers). They were very curious about how we are organized for R&D and acquisition (and the associated education and training programs), and how we conduct oceanographic research. They are most interested in cooperation in areas which are basic to a range of future capabilities, e.g., naval architecture and marine engineering, and METOC, as opposed to say 'fire control systems' where they need only buy a very few at irregular intervals. Other topics in which they expressed interest are sub rescue (apparently there was a lot of cooperation in this until about '96; and the Kursk incident has left its impact), materials, IT, and ocean science and its operational correlates like ASW (interestingly, not MCM…they never raised that as a concern and didn't respond to our few attempts to suggest it). They are very proud of some of their own capabilities -- notably sonar (we had hoped to visit the Secretary DRDO to the Defence Minister who until recently ran the

[82] They recognize that the western powers, also Australia and East Asian nations, have strategic interests in this area, and will maintain a strong presence. They also believe that China, by one of several means, will develop an IO fleet. Thus they perceive 'their' ocean as a locale for future strategic contention, and thus -- if nothing else -- an area in which oceanographic and atmospheric research should be of mutual interest. They also are very interested in improving abilities to predict tropical cyclone dynamics.

Naval Physical Oceanographic Lab, but he is still recovering from bypass surgery) and software; they spoke proudly of selling the software design package they developed for the Light Combat Aircraft, to Airbus. They also seem quite satisfied with much of their Russian equipment, especially when it has been upgraded with a combination of indigenous and imported systems. The Israelis apparently have been providing them significant help in this; Russian, Ukrainian, etc. Jews who helped design much of the Soviet equipment have since emigrated to Israel, and are very familiar with those systems.

After general and relatively high level discussions at the MOD VCNO/DCNO level, which essentially were encouraging and supportive (and conducted in excellent English and lasted far beyond the scheduled time), we spent quite a bit of time briefing ONR's program and answering questions about acquisition processes and NAVSEA with the senior naval design and engineering officers. My basic impression is that they are very interested in working with the US on all areas related to ship design -- from hydrodynamics to materials to quieting. They are proud of the ship classes they have designed and built (they design in-house), and are very curious about our new process of acquiring systems, including ships, by industrial response to government operational requirements. If indeed the US has any interest in engaging with India about the nature and structure of their future maritime capabilities, then my sense is that they are ready and willing to work with us, both to learn and to work cooperatively. Whether this is desirable from a US perspective depends of course on US views of our long term relationships with India, and the strategic importance of the Indian Ocean. As I noted above they also mentioned an interest in landing craft; although this is associated to a degree with support of the land battle, my sense is that a major driver is Navy's role, either real or potential, in disaster relief. Tropical cyclones and other environmental disasters were a topic of interest in virtually every conversation (this is a particular interest of mine, but often the topic was raised by them). Space also came up a few time, but the Indian Space Research Organization (ISRO) is one of the most capable Indian R&D organizations[83], and in addition my contacts were not in a position to discuss specific interests in cooperation in space technologies, beyond an appreciation for the importance of the area.

Our last meeting of the day was with the Defence R&D Organization (DRDO), which oversees the 52 MOD labs[84], and also funds research at Universities and industry through four Research Boards: Naval (which was our primary topic of conversation), Armaments, Aerospace, and Life Sciences. The DRDO Director Dr Pillai described India's history of S&T since Tippu Sultan introduced rocketry in 1792, as well as such recent successes as the Green Revolution, their space program, computers, and commercial software. He stated that India has core competencies in space, nuclear energy, missiles, supercomputers, microprocessors and software, as well as critical materials and devices, and the application of indigenous technology for industrial and economic growth. Among some of the interesting statistics are India's 7772 institutes of higher learning, the high global ranking of its best universities, and its 12 major S&T agencies, as well as its high tech facilities and -- from other conversations -- India's success in attracting considerable industrial R&D, to develop a 24/7 capability for research in collaboration with US scientists in different time zones. The sanctions, from Dr Pillai's perspective, can even be seen as a spur to local initiative. However one of the major continuing problems is the attractiveness to their brightest researchers, of working in US.

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[83] Why its capabilities far surpass those of the otherwise relatively mediocre Indian governmental R&D organizations is a question of considerable interest. In my discussions before dinner with Dr Kulshreshtha, who has had a long history with that organization, he opined that their capabilities resulted fro0m the personal support of the PM, which eliminated many layers of bureaucracy, and inspired a can-do risk taking spirit that is foreign to most Indian R&D enterprises.

[84] With 29482 staff including 5817 scientists.

All this was a prelude to pointed discussion about specifics of collaboration, in anticipation of our ability to work together in the very near future. There are three labs of particular naval importance -- the Naval Materials Research Lab in Mumbai (Ambernath), the Naval Physical Oceanographic Lab in Cochin, and the Naval S&T Lab in Vizak (Vishakhapatanam; weapons, stealth, shock testing, tow tank, etc). In addition to tasking their own labs (which also receive funding directly from the Navy), the DRDO Naval Research Board (NRB) funds proposals from academia and industry; and funded scientists can also use the naval lab facilities, e.g. the Marine Acoustic Research Ship INS SAGARDHWANI (Darren has a brochure). The areas in which NRB funds research (there is a specialist panel for each) are materials, hydrodynamics, sonar and signal behaviour, ocean environment, and scientific computing. This list is interestingly parallel to our own, and includes some of the areas in which we have traditionally had strong collaboration with Indian scientists.

We agreed that an appropriate next step would be for ONR/NRL personnel to look at the brochures they provided, and suggest at the next level of detail, what topics we might have specific interests in collaborating with them. Then we need to have the scientists themselves, with expertise in these selected topics, make reciprocal visits, since only from mutual interests of the researchers will effective collaboration evolve. The Indo-US Forum will meet before we can make such arrangements, and we can take their progress into consideration both because of the involved resources, and to enhance the cooperative aspects of any program that might develop. Materials, we agreed, was a good place to start because of our past history of collaboration. We were provided a copy of the proceedings of a Dec 2000 seminar on "Naval Materials: Present and Future Trends" that we will forward to Bob Pohanka and Bhakta Rath for review. They also will invite Dr Peter Majumdar to their next naval research symposium, on hydrodynamics, scheduled for February '02.

The bottom line to all of this is that to the degree the US wants to engage in military R&D cooperation with India, they seem ready and willing to work with us. We agreed that it would be desirable to identify specific cooperative projects, at an unclassified and fairly basic level, as a first step in reinitiating contact at the mil-mil level; and that to the degree possible, this should be connected to our nation-nation S&T collaboration under the Forum. Naval matters seem to be the most appropriate avenue for initial engagement, and there are some specific first-steps that can be taken while both sides familiarize themselves with mutual strategic interests and specific strengths and issues.

As an adjunct to these mil-mil/DCA opportunities, we should continue to pursue militarily relevant research under the Indo-US S&T Forum. ONR/NRL was one of the more successful participants in the Rupee program, and we should try to capitalize on this strength. As noted above, this is important both for its own sake and to help ensure that our national agenda progresses in parallel on the civil and military sides.

E. Comments and suggestions

E.1. Singapore. The US Embassy's 2001 Guide for US Exporters is entitled *Singapore - Gateway to ASEAN*. This captures very concisely my view of how we should treat it. Singapore certainly is of interest in and of itself, for strategic reasons as well as its S&T resources as

discussed above[85]. We already have a foothold here through Darren Bergan's position in the Embassy (augmented by other members of the DCA staff and the anticipated arrival of the BuMed CDR), and the IFO needs to think seriously about how to enhance the reach and value of that office. Darren will be prepared to discuss this in more depth at the all-hands, but in summary my major conclusion is that the ASEAN area warrants serious attention; my recommendations are:
- Charge the Singapore office with responsibility for ONR S&T interactions throughout ASEAN, and for coordination with APEC and other international organizations headquartered in Singapore and Bangkok (and elsewhere in the region).
- Establish close relationships with CINCPAC J4/J5 and the SAO organizations throughout ASEAN, and with STA at DOS and the EST reps at the embassies. Based on discussions with them (and the country Teams, and the US representative to APEC Secretariat), select areas of S&T focus (I would suggest IT, electronics, and life sciences). Consider collocation or consolidation with BuMed and NAVO. And, since the office will support CINCPAC, consider collaboration with USD(S&T) and the other services. Basically, make whatever you build as joint and inclusive as possible.
- The Head of Office should have the primary responsibility of coordination with CINCPAC, country teams, international organizations, and senior planners in each of the countries: i.e., a focus on investment strategies and trends. Staff should include necessary administrative support (this of course will depend on where it is located), and initially about 2 scientists, focused on disciplines identified through discussions as recommended above.
- Consider two additional staff augmentation measures: enhanced use of ATIP (we met one of the local reps and Darren will follow up), and hiring of a senior (retired) local national (like Narita-san in Japan, or like we have discussed in India). Personal relationships are very important in this area, and the office will both gain credibility and have much better access if it has a recognized local expert on the staff.
- Consider developing or supporting multilateral research programs in S&T strategy and policy, and ocean research, based on the local assets and interests that I have discussed, plus the many others that I have undoubtedly missed; and preferably, implemented through or in conjunction with existing multilateral fora in these areas. Both programs would provide valuable insight and information, as well as support US engagement agendas.

E.2. India In seems extremely likely that we will attempt to formally establish DCA relationships with India in the near future. When that happens and a naval officer is assigned to the ODC office, I strongly suggest that he or she be an EDO. My naval contacts, from the VCNO on down, expressed interest in ship technologies above all else, and if we truly wish to have long term interactions with India in 'their' Ocean, then the best way I can think of to do it, is to attempt to influence their force structure and characteristics. An EDO who is familiar with the NAVSEA organization, the Warfare Centers, and US ship and ship systems R&D programs, would make the ideal DCA representative.

Until that time, Darren Bergan and other representatives of ONR's IFO can and should provide significant assistance, via Maj. White and Marco DiCapua (both are important for coupling S&T to security issues). The following specific recommendations for ONR/IFO derived from our discussions:

[85] In particular, there are a number of areas that should be followed up with detailed visits: the University in JB; DTRO, the actual labs of DRO, CSO and SCO, and the 16 NSTB Centers; APEC (including ISTWG and OMISAR) and PECC; the other University, and the Polys; other Ministries and their R&D labs (e.g., Ministry of Environment); other labs at NTU and NUS; and ATIP.

- Howard Bunch's proposal to visit Indian shipyards to teach his course and assess the degree to which they have used their software capabilities to enhance their shipbuilding capabilities, should be approved. Dr DiCapua agreed that his study would be a good test case on what is and isn't working in India's system development programs (we had an interesting discussion about the apparent dichotomy between the success of ISRO and relatively mediocre performance of DRDO). Howard's program should be carefully coordinated with Maj White and Dr DiCapua; the Indian Navy needs to be aware of our efforts, and perceive them as supportive of their desire to develop improved cooperation in this field. Ideally, this program should be perceived by the hosts as a response to their interests, and an initial step toward broader collaboration in NA/ME; it should also be seen as an aspect of DCA activities, as well as an ONRIFO project. Coupling to our EST interests would also be appropriate. This may require some modification to Howard's original plans, but at this point his visit should become part of our overall long term plan for engagement, and not simply an isolated IFO study.
- At DRDO, we agreed that the 'next step' between us would be for ONR scientists to review the literature they gave us, and then send a letter suggesting the research topics in which we have particular interests. We also agreed that the initial contacts should be in the area of materials, since that is where we have had the strongest collaborations with their Universities to date. Darren has the materials (the NRB brochure, and the Symposium report), and will get them to Bob Pohanka and Bhakta Rath for their review (perhaps via the All-Hands meeting). We noted that the Forum committee will have met before this can occur, and that our response will be influenced by those discussions. Any such letter, which can and probably should be informal, should be forwarded via Darren and Maj White; phonecon coordination is appropriate. Following that, reciprocal visits would be in order. I would suggest we first invite a DRDO Naval Materials Lab contingent to visit NRL, followed by a visit of our scientists to their lab, perhaps in conjunction with a review (inviting their naval/DRDO personnel to join us) of our past Rupee-fund research. A CSP-supported Indo-US materials workshop might be a very effective mechanism to spur this collaboration, and interconnect Indian civil and MOD researchers…if, that is, ONR/NRL decide, in conjunction with CINCPAC and the country team, that materials research would be a reasonable way to capitalize on past strengths as we move forward.
- The next DRDO naval seminar (scheduled for Feb 2002) will be on hydrodynamics. CDRE Das of DRDO agreed, at my suggestion, to invite Dr Peter Majumdar to this seminar. Darren will assist with coordination. Their brochure implies that they have some interesting facilities at two of their labs; Howard's study -- if approved -- will shed light on their software capacity; and this aspect of S&T is basic to the path of DCA collaboration that I have already recommended. Thus it is a logical candidate for serious attention, and an invitation to the seminar is a good way to get started. I am sure that Peter can augment my comments. I am recommending that this follow the contacts in materials only because of timing and the ongoing collaborations. NA/ME and other aspects of ship technologies will be a 'new' area of close cooperation, and should therefore build upon established strengths. Further, since it should become our major path of collaboration in the future, we should be very deliberative about how we proceed. Howard's study is a good start and may help open doors -- it has the advantages of being somewhat academic in nature -- but it is logically followed by direct navy-navy involvement such as their seminar offers. This S&T lead, via the seminar, could then be logically followed by more systems-oriented contacts through whatever ODC organization evolves.
- The third major opportunity for collaboration with India is METOC. With COAMPS now openly available, and our interest in tropical cyclones, it would seem only logical to me that we capitalize on their research capabilities, their data, and their interests in collaboration. This is an ideal area for multinational cooperation, particularly with Australia's BOM and their research center. Such a thrust also capitalizes on NRL interests, and the associated inclusion of environmental research in the Forum agenda. I believe we could also generate NOAA and NSF

support for any such effort -- perhaps as a component of the IOMI initiative. All my Navy contacts evinced sincere interest in this area, as well as the correlated aspects of disaster management. If we want to move forward in this area, which I believe we should, then my recommendation is that the envisioned program be multilateral and oriented to severe weather and disaster management. This would tie in whatever evolved to CINC objectives and programs, as well as international and US interests in tropical cyclone analysis and prediction. We may need a US-only conference to generate a coordinated approach.
-Finally, wrt a local hire like Prof Raj Gopal, I recommend we continue to hold off pending the development (or not) of a DCA relationship. While I believe that ultimately local support will be important, we should not at this point get out ahead of other more official actions.

My bottom line is that there is every likelihood that we will very shortly be prepared as a nation to reinvigorate our mil-mil and S&T collaborations with India, and that ONR has an interesting, perhaps unique, opportunity to play a leading role in advancing the US international agenda while simultaneously meeting its own demands for quality and rigor. ONR IFO should therefore work very closely with STA at State as well as CINCPAC and OSD to scope its role to complement the rest of the national program. My India experience on this trip reinforces my belief that the value of IFO lies not as much in its isolated contributions to the ONR PO's portfolio, but as a leading component of our overall national agenda. If ONR rejects this fundamental philosophy, then I can simply suggest that we ignore mil-mil aspects and focus on funding support to and through NRL via the Forum. This 'minimalist' approach would at least enable ONR to maintain its scientific contacts and the associated, well recognized, benefits.

Itinerary (Darren Bergan accompanied me on all visits and has contact details; thus none here)
Singapore
31 August, Friday: Arrive Singapore ~1430. Host Darren Bergan. RON Regent Hotel
1 September, Saturday: AM: Singapore Botanical Gardens
PM: Little India; report preparation
2 September, Sunday: AM: Julong Bird Park
PM: Report preparation
3 September, Monday (Labor Day) AM: Singapore Zoological Garden
PM: City center, Raffles; report preparation
4 September, Tuesday: AM: NAVOCEANO Branch Office; Asia-Pacific Economic Cooperation (APEC) Secretariat
PM: DSO National Laboratories; AMEMB Country Team Brief
Dinner: DCA reps and Dr Gerry Yonas, Sandia Labs (w/wives)
5 September, Wednesday: AM: Nanyang Technological University
PM: National Science and technology Board
Dinner: Dr & Mrs Viatcheslav Yastrebov, RAS & NTU Robotics Research Centre
6 September, Thursday: AM: Office time; Defense Science and Technology Agency
PM: (1) Tropical Marine Science Institute, National University of Singapore
(2) Temasek Laboratories, NTU/DSTA
7 September, Friday: AM: National University of Singapore; ATIP; US Embassy
PM: Defence Medical Research Institute
8 September, Saturday: Chinatown; Kampong Glam
Dinner: Dr & Mrs Viatcheslav Yastrebov, at NTU
9 September, Sunday: Transit to India
India (Major White has cards and contact details)
9 September, Sunday: Arrive ~2140; Host Maj Rick White, USA; RON Maurya Sheraton
10 September, Monday: AM: Breakfast with Maj. White; Embassy Discussions with EST

Counselor Marco DiCapua and Capt Eric Nelson, Naval Attaché
PM: Institute for Defence Studies and Analyses, Director K. Santhanam, Deputy Director Cdre C.Uday Bhaskar & Staff
Dinner: Home of DCM Mr. Albert Thibault, iho Dorman

11 September, Tuesday: AM: (1)Ministry of Defence Joint Secretary (Planning and Coordination) Mr. B.A.Roy
(2) Vice Chief of Naval Staff, VADM
(3) Deputy Chief of Navy, Vice Admiral Puri
(4) Director General Naval Design RADM N.P.Gupta & Staff
PM: Defence R&D Organization, Chief Controller, R&D Dr A. S. Pillai, Cdre B.B.Das and staff; Embassy; Report Preparation
Evening: Depart for Singapore and Perth

Report 8: 12-30 September 2001: Australia[86] - Part 1: Western Australia, Sydney, Canberra

A. Western Australia Observations
B. Western Australia Visits
C. Sydney Observations
D. Sydney Visits
E. Canberra Observations, general comments
F. Canberra Visits
G. Initial Conclusions and Recommendations
Itinerary

A. Western Australia Observations

One of the principal objectives of this entire trip is to determine whether or not there is adequate S&T in Australia to justify staring an ONR IFO Branch office on the continent. If the rest of Australia has anywhere near the level and amount of S&T as Western Australia (WA), then the answer will be a definite yes. Indeed, the presence of Australia's entire submarine fleet and many of its surface combatants at Stirling, RAN's emphasis on experimentation, the significant shipbuilding industry between Rockingham and Freemantle, WA's plans for major investment in the marine sector (and its bid to take over submarine refit), the oil and gas industry off the northwest coast, the four universities in the Perth region, and the diversity of both commercial and academic R&D activities -- combined with the distance from both Singapore and the eastern side of the continent -- might well argue for at least a Navy lab/NFFTI presence in Perth, as the strategic relationship between the US and Australia evolves.

WA, or at least the southwest part we visited, has historically been strong in mining (gold, bauxite, nickel, mineral sands), forestry, and farming (wheat, sheep). More recently, it has augmented its industrial capacity with refining and commercial shipbuilding (55% of the national total), and support of the offshore oil and gas industry. It is now making a bid to become Australia's "Marine State"; and with its significant resources from mining royalties, plus the payroll and land taxes, the state is able to invest very heavily in marine infrastructure, as part of its efforts to attract industry and also convince the commonwealth government to transfer federal maritime activities there. Among the investments are a $200M development of the Jervoise Bay marine industry precinct (about 20km south of Perth); this will contain a marine support facility, Marine Industry Technology Park, and -- if and when approved and an industrial sponsor is found -- a world class hydrodynamic test facility, designed specifically to deal with the challenges of deep water oil and gas production. In addition, DSTO's Stirling contingent is growing, CSIRO and AIMS are both increasing their complement of its marine research staff in the area, and there is a successful commercial ocean and meteorological analysis and forecasting industry that supports the offshore oil and gas industry (and probably has more data on conditions in the area than the government).

In addition to its extraction and heavy industry, the area around Perth is in the process of developing high technology business. With four universities that together can accommodate over 65K students (Curtin University of Technology, University of Western Australia, Murdoch and

[86] I had intended to include a general discussion about Australian S&T strategy and programs in this report, but it is already so long that I will put this in a separate paper. Although that more detailed assessment will be needed to help substantiate my views, I believe that I am confident enough at this point to draw some basic conclusions and make some specific recommendations for ONR's next steps. These are included in sections E and G.

Edith Cowan -- I visited the first two) and many research 'centres' at the University, State and national level, it has a diversity of expertise and many opportunities for growth. UWA and Curtin are strongly pushing 'applied' research and the formation of start up companies. Among the new initiatives I was briefed on at UWA, to cite just one example, are CTEC, a Centre for Medical and Surgical skills that provides advanced on-site and remote training for the Australasia region; Advanced Nano Technologies, a new joint venture between a local startup company and Samsung Corning of Korea, that has recently patented a low cost mechanochemical process for synthesis of nanopowders; and a new $50M Motorola software engineering center -- part of their global software group -- that will complement those currently operating successfully in Sydney and Adelaide (and other countries, developing products by handoff across time zones on a 24/7 basis). There is much innovation. Indeed the one complaint I heard about the federal Cooperative Research Center (CRC) process is that it requires cost sharing by industry, and is therefore biased against new ideas where there is not yet a commercial base; photonics is an example of what can happen when a university professor's research leads to a major new Australian industry, but the current process seems less open to such bold and risky new ventures.

Overall, then, WA, at least around Perth, is very much in a growth mode. Abundant natural resources, good educational facilities and human resources, proximity to Singapore (closer than Sydney), close intellectual connections to Europe and America, naval presence, and a dynamic attitude combine to generate a vision of a prominent WA role throughout the Asia-Pacific region. Most of the ocean-related researchers I met were familiar with ONR and the IFO, and had worked closely with Navy lab personnel or US PIs supported by ONR. If over the coming decade the Indian Ocean becomes of more strategic importance to the US, and our submarine-oriented collaborations with the RAN grow, then Perth will become a very logical locale for increased Navy R&D attention.

B. Western Australia Visits

Stirling: DSTO has a 40-person contingent of its Maritime Operations Division at the Stirling naval base in Rockingham. Located in the lee of an island about an hour's drive south of Perth, the base offers both security for the RAN submarine fleet (and a half dozen frigates) and convenience for the families[87]. The DSTO contingent was moved here in 1995, and is expected to grow to about 67 staff, to support upgrades to the submarine fleet and RAN's thrusts in experimentation. It is focused primarily on front line support, in particular integration of the augmentation equipment into the subs' combat systems. Personnel skills are about equally divided between ops analysis (tactical development and future capabilities), sonar technology, and combat systems. My host Dr Chris Davis gave me a basic introduction to DSTO, described the work of the local group, and accompanied me on a short windshield tour of the base. One significant new Navy program is 'Headmark' (a parallel to Army's 'Headline"), managed by the Australian Maritime Concept Development Group. The idea is to move toward a force structure focused on concept rather than capability. This approach accompanies the emphasis upon experimentation, within a 'Joint Experimentation Framework'. RAN is already starting to think beyond the Collins class subs, under a project entitled Sub 2020. A submarine S&T workshop is scheduled for this December, to outline the technological and system concepts that will be the basis for the experimental package in coming years. Among the concepts being discussed are AIP, UUVs and offboard sonars, nonferrous materials, double hulls, increased automation, and

[87] There were no subs in port during my visit; the operational tempo is very high, and partly as a consequence one of the RAN's problems is retention. This, plus the large and growing commercial marine industry in the area, are part of WA's argument for moving the refit capability west from Adelaide.

advanced communications. On this last, they had considerable success with the Nautronix equipment during the recent US-Australian PCO/PXO exercises.

Nautronix is a Freemantle based company with a worldwide staff of about 350. Its three divisions service the oil and gas industry, defence, and mining; the first two are closely related, and are based upon Nautronix's technological strengths in acoustics and vessel controls. The company started about 15 years ago, developing acoustic systems for the offshore oil and gas industry. It has since grown largely through acquisitions, a recent example being Maripro of Santa Barbara, acquired from SAIC. We spent much of my short visit discussing their spread spectrum, LPI acoustic communications system which was installed on the USS Ashville and HMAS Sheean during the recent PCO/PXO exercises. Due to a somewhat fortuitous failure of some of the range support equipment, it was extensively used (over 600 messages transmitted) for operations and test control. Although designed principally for LPI tactical applications, these exercises demonstrated that the system can be readily installed and use existing transmit and receive transducers to provide safety and control during multinational exercises.

IOC & Roundtable: With support from WA and the Australian Bureau of Meteorology, the International Oceanographic Commission has opened an office in Perth, largely to develop the Global Ocean Observing System (GOOS) in the South Pacific and Indian Oceans. The intent of the local office is to form a core group in Perth, based on the scientists in the universities, CSIRO, and the offshore support industry, both to promote WA GOOS (they are looking for support from oil and gas companies, particularly Woodside, which dominates in the area) and to serve as a resource for the region. A strategic plan for SOPAC was developed last year, and the current focus is on planning for the Indian Ocean. A 'core group' of about 20 scientists will meet in New Delhi this November to start the process and generate support, to be followed by a major conference next year.

We had a roundtable discussion with about a dozen local representatives of the BOM, CSIRO, and local industry. There is considerable oceanographic data on the conditions off NW Australia, but most of it is proprietary to the oil companies; the WA and federal government ocean research was largely associated with fisheries, and has now stopped. I was shown some very interesting new data which has evidence of extremely strong but short bursts of high speed (~2m/sec) currents near the bottom during some changes of tide. These have great significance for planning pipelines and seabed facilities, and imply the need for very high frequency sampling to help understand the associated physics.

Both industry and BOM reps stated that it would be very valuable to be able to extract environmental data from the Defence OTH radars that surveille the waters off the north and NW coasts. This is a breeding area for cyclones, and a significant percentage of them 'recurve' toward the continent. There is little detailed scientific data about these storms; apparently only one has ever been flown, and that one by the US (and not off this coast). The local BOM team has worked with NRL Monterey on the prediction of the paths of such storms, and would like to continue this collaboration.

Interestingly, most of the roundtable participants were familiar with ONR, and one group -- the Remote Sensing and Satellite Research Group at Curtin - has a NICOP proposal with BOM and the University of Wisconsin to conduct laser propagation studies across an open water marine range in the area (I had similar discussions later with a PI at UWA who has worked on these issues with SPAWAR).

Curtin University of Technology: Curtin is a relatively new University, with an enrollment of over 24K students. Prof. Rossiter, Deputy Vice-Chancellor for R&D, noted that Australia as a whole, and WA in particular, 'punches above its weight' in R&D per dollar since Australians are

used to doing more with less, and much of the infrastructure is built in through the educational system. With only a very small domestic market, they also are very outward looking, and are reluctant to invest unless they believe they can develop competitive world class capabilities. Curtin is particularly strong in technologies associated with the resource sector[88], with additional strengths in ICT, health sciences, and 'livable communities'[89]. One project that particularly interested me was a continuous, cost-effective process to make hydrates from natural gas. This will be particularly useful for stranded gas deposits and sour gas (since the process purifies the gas), and makes it convenient to transport, particularly to arid regions where the water can be as valuable as the gas. Another interesting project is a scalable LNG process that can be used for conversion at the well head. Woodside Energy Ltd is their commercial partner for these processes, and has invested $1.8M over three years in the Woodside-Curtin Hydrocarbon Research Facility, which will support a Natural Gas Hydrate pilot plant.

In general, Curtin is shifting strongly to strategically oriented research in alliance with commercial partners in order 'to produce a significant difference in the world'. While many Universities throughout Australia are saying the same thing, Curtin has taken some significant measures to manage its portfolio of research activity. As part of this processes they are mapping their disciplines to the needs and interests of WA. They use the Balanced Scorecard approach for both R&D and teaching and learning, and carefully allocate resources and positions in conjunction with their strategy and performance metrics. They are also piloting promotion processes that reward the new expectations, and they recruit differently, emphasizing industrial as well as teaching expertise, particularly for research leaders in multidisciplinary matrixed areas. They believe that partnerships are critical, and are enthusiastic about the WA-CSIRO University Postgraduate Scholarship scheme which will provide $500K annually over the next three years for PG students working on projects of mutual interest to the Universities, CSIRO and industry.

I was primarily hosted at Curtin by Prof. John Penrose who heads the Centre for Marine Science and Technology. Created in 1985, CMST now has about 16 researchers, and is recruiting for two new senior faculty positions in marine acoustics and hydrodynamics[90]. In general, their strengths are in acoustics and bioacoustics, ship/yacht and underwater technologies, and applied oceanography. I briefed ONR's interests and programs, and in turn heard short presentations about a number of ongoing CMST and related projects: radiated noise measurements using a ship's own towed array; viscous flow around moving flat plates (thin keels, control surfaces); spatial variability of near surface sediments using wavelet processing; the remote sensing group and its projects; electrochemical sensing of the biologically active portion of dissolved metals; biological sea noise (including the measurements with the Thai's, see Report 6); biomass assessment with acoustics; a major program with CSIRO to acoustically classify the benthic structure around the coast (4 categories: soft/hard, smooth/rough, which correlate with fish type); ROV video and dynamic station keeping; and ship motion in heavy seas. Although all CMST research staff are on the payroll of the university, the total support from Curtin covers only about 1.5 FTE. About half of their 'soft money' support now comes from DSTO (largely for acoustics), and the rest from commercial sources. While they have some small craft for coastal work, like

[88] With CSIRO, the University is developing the Australian Resources Research Centre, "the major oil and gas research facility in Australia, and of significance on an international scale" (brochure).

[89] The Australian Housing and Urban Research Initiative, a major national initiative undertaken jointly with Murdoch University.

[90] These two positions, like most in WA universities, are limited term appointments. There is no more tenure system; at best, some positions are 'continuing' which simply means the incumbents can remain until they are 'made redundant'.

most Australian ocean scientists they rely on commercial hire for most of their at sea research[91]. CMST works closely with the WA Department of Industry and Technology on its marine initiatives, and has been designated a WA "Centre of Excellence' in marine S&T. They have been working for several years to get a waterfront facility south of Freemantle, and also have developed a proposal for a major (50x50x20M) hydrodynamic test facility to support the offshore industry.

UWA: The University of Western Australia is WA's first University, founded in 1911. It prides itself on being the leading research university in the state[92], as well as having very high academic standards. UWA has over 14.5K students with an academic staff of about a thousand. It has faculties of economics and commerce, education and law; agriculture; arts; engineering and mathematical sciences; medicine and dentistry; and science. It also has several Special Research Centers including the Centre for Offshore Foundation Systems, as well as many University centres and laboratories. As noted above, UWA will also soon host the new Motorola software engineering center, that expects to have a staff of up to 400 (Motorola made a presentation about their plans and operations to staff and students at the same time as my visit).

I met over lunch with Pro-Vice Chancellor Prof Barber and several senior members of the faculty, then visited the Departments of Psychology and Electrical and Electronic Engineering, and the Centre for Water Research. Prof. Faraone, Head of the EE Dept, also heads its microelectronics research group which has nine academic and research staff and 10 postgraduate students. This group specializes in HgCdTe IR sensors, and UV photoconductors. Among his facilities is a mercury cadmium telluride molecular beam epitaxy facility provided by DSTO to support his IR sensor research. The group also has capabilities for VLSI and EO system design, semiconductor fabrication, and material and device characterization. Their semiconductor work couples closely to their research in IR and UV propagation in the marine atmosphere.

The Psychology Department has some 1200 undergraduate and over 100 graduate students, and 25 faculty. My hosts described their work in nested multi-level analysis of organizational processes, which started with an assessment of the difficulties experienced by livestock companies when they attempted to automate their slaughterhouse floors. This led to the development of a new model that has been successfully applied to a large number of complex organizational problems. With seven other research-oriented University groups they are now beginning to work with DSTO to help examine military issues, and were therefore very interested in the types of human-related problems ONR is tackling[93].

My host at the Center for Water Research, Prof. Pattiaratchi, has an ONR grant to support his sediment transport work as part of the mine burial program. He is also UWA's coordinator for all of their marine science and engineering, and stated that some 50 researchers are involved in fields ranging from his own physical oceanography, to sea grasses, to oil and gas engineering. The CWR itself, headed by Prof Jorg Imberger, has 8 academic staff and takes in about 35 undergrads per year. It has expertise in hydrology (surface and ground water, hydrological geology), coastal oceanography, GFD, and environmental fluid dynamics. Since Australia's CRC scheme depends on industrial partners which are scarce in these fields, they have made a deliberate decision to seek international support. Their largest customers are in South America, and they also do work funded by Israel, Germany and Italy.

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[91] Australia has one ocean research ship, the *Franklin*, and one large fisheries research vessel, the *Southern Surveyor*. Time on these is awarded competitively. The Antarctic resupply vessel *Australia* also can support some research.

[92] It is the best in the nation in terms of national competitive grants per capita. One of my hosts noted that researchers are only allowed to have two large ARC grants at a time; therefore the strongly competitive departments often 'share' research projects among faculty.

[93] I suggested they contact Yvonne Masakowski

I had some interesting conversations concerning ONR support at UWA. Prof Barber asked about allowable indirect costs; Prof. Pattiaratchi commented that one of his problems in getting his grant was certifying that UWA was a drug free environment, since they have no formal process to this end. Prof Imberger opined that now may not be a good time to open an office in Australia because of local paranoia in the scientific community associated with the US situation and concerns about working with the military; but felt that there nonetheless were opportunities for us because Australian students and researchers are innovative and not afraid of risk, and overhead costs are quite low. Overall, as at Curtin, all the senior faculty had close collaborators in the US, and many were familiar with ONR and its programs. In general, I found the atmosphere on WA campuses little different from that in major US public research universities.

C. Sydney Observations

Sydney, or rather the State of New South Wales, appears to be a bit more laid back than many of the other states with regard to seeking new opportunities through S&T. With the oldest and some of the best academic institutions, and much of both the population and the major business of the country, NSW apparently sees little reason to invest heavily in research. Since this puts its universities at a disadvantage in seeking federal grants (such as those for major national research facilities) where state cost sharing is important[94], it will be interesting to watch the dynamics over the coming years, particularly if students and faculty become more internally mobile[95].

That said, Sydney certainly seems much more international, diverse, and cosmopolitan than the WA institutions I visited. This could in part be due to the relative ease of international transportation; it may be a long way to almost anywhere outside Australia from Sydney, but from most other locations in the country, you have to go through Sydney first. Almost everyone I spoke to had either studied in the US or Europe, or regularly attended conferences there; most were familiar with ONR, and several knew our POs (and Miriam Baltuck, the new S&T Advisor to the US Ambassador in Canberra) personally. On the down side, at least judging by attitudes, this relative familiarity, combined with the sense of being a small part of a large city, plus the federal and NSW reluctance to strongly support academics for the past few decades, has exacerbated the NSW 'brain drain'. US academic salaries are about double those here, and US universities offer better opportunities for frequent, easy interaction with peers. The temptation is often too much to resist when there appears to be a lack of appreciation at both federal and state level.

My stay in Sydney was deliberately short, since of all the locations in Australia, it is best known to the US S&T community[96]. In spite of the briefness of my stay however, it was rapidly apparent that Sydney has a great deal to offer ONR. It has a roughly similar population and university complement as Singapore or Hong Kong, and its academic institutions have well deserved

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[94] One example is the nation's first synchrotron; there were three bids, but Victoria put $100M on the table and won. Somewhat reminiscent of the University of Florida and MIT re the US national hi-mag lab a number of years ago.

[95] As noted above, the University system was basically designed to provide tertiary education to undergraduate students in their own states. As opposed to the US system however, graduate students also typically stay at their undergraduate university for their advanced degrees, and many faculty also return to their own institution.

[96] I skipped DSTO Sydney because we had many ONR POs and PIs at its recent MCM conference; I did not visit UNSW, one of the 'Group of Eight' major research universities, because Fred Saalfeld's party had appointments there and I was asked not to overlap. Etc.

international reputations. And, perhaps because of Sydney's financial dominance in the federation, and its closeness to Canberra, the senior researchers I met there seem to have both a very good appreciation of federal activities, and considerable influence. Like everywhere, proximity counts. I gave Sydney short shrift only because my own visits have least relative value added here. And, as noted in my visit comments below, even in my short stay I found two of the most exciting ONR-relevant S&T developments (and a third of personal interest for my environmental studies) that I have seen during this entire trip. In general, then, my Sydney visit reinforced the impressions gathered in WA, that there is more than adequate high quality S&T in Australia to justify our close and detailed attention[97].

D. Sydney Visits

AODC: My intent had been to visit Ben Searle, the Director of the Australian Ocean Data Center[98], at AODC's Sydney Headquarters; but parking near the facility was restricted because of increased security, the staff was at sea on one of the hydrographic vessels, and Ben himself is on a 2½ month service leave at the University of Technology (UTS), Sydney; so instead we met downtown for a cup of coffee. AODC functions as a national data center but reports to the Navy's Director of Oceanography and Meteorology, a Commander, who in turn reports to the Hydrographer, a Captain. Commensurate with other Defence cost cutting measures, the Hydrographer's budget has been reduced by about 20%, and they are even thinking about tying up one of the two hydrographic ships. AODC's staff has been reduced from 15 to 6. Dr Searle noted that although the Navy is thus significantly impacting what is essentially a federal function of data management, it is reluctant to turn over the responsibility to any other agency; and he has not been permitted to participate in the federal Marine Data Group that addresses the associated policy issues and has suggested greater involvement with the states.

For several years, Dr Searle has been promoting the development of an international standard Marine XML (marine data markup language) -- a single, unified framework for marine data that would be compatible with all legacy data management systems and formats. He has recently taken leave to work with IT scientists at UTS[99], other Australian Universities, and international colleagues, to establish a Consortium for this purpose[100]. This will be similar in intent, but less costly than, the Open GIS Consortium. In addition to developing a common global standard -- a matter of some time criticality since many communities are now adopting XML, and unless there is international collaboration it can be expected that there will again be several, if not many, XML approaches to marine data just as there are already thousands of data

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[97] In addition to specific programs of interest, Australia has considerably better access than do we, to China and SE Asia. Many of the Universities have very active teaching and research programs throughout that relatively more diverse and logistically complicated area, thus we could improve our own knowledge through closer interactions with academics and industry here in Australia. Similarly, Australia's own natural characteristics often seem to give its researchers a slightly different 'take' on problems or technologies that are of equal interest to us. While this is particularly true in environmental and biomedical research (including sensors), it has impact also on fields such as IT and BT.

[98] Dr Searle is well known in the international ocean data community. He chairs IODE of IOC, which has some 70 member countries. I have met him several times, most recently at an ocean data conference in Ireland in 1997.

[99] I asked why UTS. They have traditionally been a teaching university, but are interested in increasing their involvement in research, and managing an international standards body would support these efforts. They are thus willing to focus their own XML research in this direction.

[100] The Consortium will have four levels of membership, from affiliate to strategic, with costs ranging from US $2K-$10K/year. IOC and ESRI are among the first members. ESRI's interest is to extend the utility of GIS and ArcInfo to the marine community.

formats -- some additional research to extend the level of abstraction of document type definitions will be required[101]. He has been discussing the possibility of support for this research with the EU and US colleagues. Dr Searle has been in contact with NAVO which itself is considering an XML development and showed interest in the proposed Consortium, and through ONR with OCEAN.US and Peter Corneullion at URI who is developing DODDS for the US community under NOPP; he will work with Peter to discuss efforts to enhance global commonality of the various approaches.

US[102]: University of Sydney is one of the "Group of Eight", the largest and strongest of the nation's Universities[103]. USydney has about 40K undergraduates, 3K graduate students. My host Prof Field stated that they have a very strong medical group, also engineering and science (including many in marine science), and math. By and large, USydney has been academic rather than industrial in its approach to research, but this is changing; and they are aggressive regarding IPR and spinoffs. Like the other federally funded universities, government income is based on a formula that considers both load and performance. Among the government initiatives being pushed through this carrot and stick approach are increased student mobility (they currently get 80% of their students from NSW), completion of the PhD within 3½ years, applied research and cooperation with industry, and establishment of critical mass in 'centers of excellence'[104] able to tackle large problems.

Prof Field also noted that after last week's terrorist attacks on the US, they saw a major increase on campus, in interest in IT and connections to the fast internet. He opined that this trend may have the effect of 'dragging Australia closer to the rest of the world'.

Center for Field Robotics: This 'Key' Centre'[105], under the leadership of Prof. Hugh Durrant-Whyte of the Dept of Mechatronics[106], was awarded about $1M/year for 6 years by the government, but still receives about 80% of its funding from industry. The principle sponsor for the multiple-AAV work I discussed with Dr Sukkarieh (who stood in for Prof Durrant-Whyte) is BAE Systems; but they also do a lot of work for mining and heavy machinery companies. The group has a staff of about 8, ~60 mechatronics undergraduates, and some 40+ PhD students, 30% of whom are international (including 2 who just joined from MIT). They also offer training for industry in their advanced techniques. The PhD program is designed to be 3 years long; the first year the students do hands-on work in a navigation or control problem as part of a team, and define a problem for their thesis research. 'Systems' constructs are central to their approach, and systems engineering education begins with the undergraduates.

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[101] His draft proposal described research underway at UNSW, UTS and University of Sydney. I discussed similar 'semantic web' and ontological research in other fields with a crystallographer at UW. This is apparently an area of considerable research interest and strength in Australia; see also the comments from Peter Beadle of Motorola below.

[102] This has been the only visit so far where the schedule was a bit fouled up. In addition to the Pro Vice-Chancellor I got to see only one other group, albeit that one was very interesting.

[103] One in each capital city, but 2 in Sydney and Melbourne. The other one in Sydney is UNSW. These Universities, I was told, receive 70% of the competitively awarded grant money and have very broad strength across all major disciplines, usually including medicine and law. Others have 'niches' of expertise but not critical mass across the board.

[104] Australia has many mechanisms to encourage the formation of 'centers' both within universities and between many universities, the state (CSIRO) and industry. Linkage grants, CRCs, and Special and Key Centres are examples.

[105] As noted above, Key Centres do both teaching and research, but do not necessarily require industrial cost sharing. It is worth noting that this group is the one most strongly commended to me by Stephen Hood, the DSTO rep at the Australian Embassy in DC.

[106] A combination of mechanics, electronics, and computers - with a strong systems focus

CFR's main expertise is in navigation (particularly what they called high integrity navigation, combining precision with fault detection and reduction of uncertainty), control, and systems engineering, and they use a combination of land, air, and underwater vehicles to test their algorithms and theory (they claim that central to their work is its basis in proven mathematical optimality). I saw a number of examples from their research demonstrating precise control of large mining and stevedoring equipment. The most interesting aspect of their work from my perspective was the BAE sponsored ANSER (Autonomous Sensing and Navigation Experimental Research) project with multiple (4, to start with) AAVs, which is apparently targeted for application in the UK "Watchkeeper" program (nfi). They use their own AAVs (termed 'Brumby's), that can carry a set of interchangeable sensors (e.g., lasers, 77 & 94 GHz radars). In the first phase of this work they have demonstrated decentralized sensing and SLAM (simultaneous localization and map building)[107] based on their control theory and algorithms, and have simultaneously tracked up to 40 moving targets. They are now working on decentralized data fusion, and associated multiple platform autonomy with decentralized control (this work is funded by BAE and is proprietary). They have presented their work to BAE's Systems North American divisions as well as to their headquarters and the Australian Missiles and Decoys group. Dr Sukkarieh stated that to date this work has been funded by BAE in the UK, but that they believe BAE would be interested in increased collaboration from its NA divisions, and possible ONR support. This is not my field of expertise, but the briefings I received were extremely impressive (the research seems to be much further along than anything I had seen in the US), and certainly their approach has the sort of 'network centric' features that we are interested in. I strongly recommend IFO London follow up with BAE[108], both to learn more about the program and to determine whether we might want, and would be allowed, to participate. At a minimum, we need to thoroughly understand and evaluate this group and its research.

Macquarie University: Macquarie is located on a large plot of land in the northwest suburbs of Sydney. It has a student body of about 20K, with 6K graduate students, about 900 of whom are in PhD research programs. My host Prof Bergquist is a renowned expert in unculturable extremophiles, and maintains a very active international research program in addition to his administrative duties as Deputy Vice Chancellor. I also met Dean of Graduate Studies Trevor Tansley, whose work on nitride deposition at low temperatures is partially supported by ONR; Dean Tansley is a long-time colleague of Colin Wood. We spent little time discussing programmatics and the University as a whole, rather my visit comprised meetings with four very interesting and impressive research groups.

Microbiology: Dr Michael Gillings of the Key Centre for Biodiversity and Bioresearches "uses DNA methods to detect, identify and track microorganisms directly in environmental samples…aim to understand the distribution and roles of microorganisms in ecosystems by analyzing phylogenetically informative genes and by analyzing genes that play a role in key environmental processes" (from short cv). Their work is differentiated from others by its focus on functional genes, and screening and exploration using environmental DNA samples rather than the organisms that contained the DNA. They have just received an ARC grant[109] for developing

[107] They claim to be #1 in the world in SLAM. Much of this work, I was told, has been published.

[108] The UK contact is Dr David Hartley, Head of Capability, Autonomous Systems, BAE Systems; Future Systems, Lancaster House, PO Box 87, Farnborough Aerospace Centre, Farnborough, Hampshire, GU14 6YU, UK. Dave.Hartley@baesystems.com; +44 (0) 1252 384952 fax 384981, mobile 07802 358791)

[109] The latest round of ARC 'large' grants were just announced prior to my visit. This occasioned considerable discussion about the process at most of my meetings. In Dr Gillings' case, he was extremely disappointed since he received only about a third of what he requested; this will force him to significantly change his approach -- he had wanted to prove out his prospecting methodology before seeking industrial support -- and may mean the loss of a trained technician.

this procedure into what they term "molecular prospecting", targeting genes with known ecosystem functions and potential, and 'mobile gene cassettes' (integrons).

Dr Paul Attfield of the flow cytometry group described the work of himself and Assoc Prof Duncal Veal with the water supply, dairy, and food and beverage industries. They are combining fluorescence signaling with cytometry to rapidly (hours) detect and enumerate microbes to the species level. Dr Attfield provided me with a number of their papers on the methodology[110] and its applications, including results of detection of *Cryptosporidium* and *Giardia.* Many of their advances have come through collaborations with the Macquarie laser group (see below) combined with microfabrication and DSP, plus the use of fluorescent antibodies for labeling microorganisms according to expression of particular antigens. The work of both these groups should be of interest to MEDEA-related developments regarding EID and environmental relationships.

GEMOC: The National Key Centre for Geochemical Evolution and Metallogeny of Continents is headed by Prof Sue O'Reilley. GEMOC's mission is to "create a new paradigm for the formation of metallogenic provinces by undertaking fundamental research on the evolution of the upper 200 km [lithosphere] of the earth's crust-mantle system, integrating petrological, geochemical, and geophysical information…to give Australia's minerals exploitation industry a competitive edge into the 21st century by transferring this new knowledge base and the methodologies to the industry and to the next generation of students" (brochure). Prof O'Reilley was joined for my briefing, and a tour of their exceptional analytical facilities, by Dr William Griffin who is seconded from CSIRO[111] to head the GEMOC technology development program (which focuses on in-situ methods), and Dr Malcolm Walter, who is in the process of standing up a new Australian Centre for Astrobiology[112]. Among GEMOC's major contributions are improved understanding of crust-mantle interactions and the ability to determine whether the mantle has been involved in the development of geological domains, which provide a new framework for terrane analysis for minerals exploration. They have unique methods for dating mantle formation events and the times of overprinting tectonic events, and have used these techniques to develop a 4-D lithospheric mapping methodology for large scale analysis of crustal history (being commercialized as "TerraneChron" ™). They have a world-class "facility for integrated microanalysis" that links measurements from several trace element and isotopic analysis instruments, through a 'micro-GIS' procedure to combine spot analyses with spatial variations in composition. Basically, GEMOC has integrated expertise in geology, geochemistry, and geophysics, to understand global geologic processes through trace element fingerprinting and micro analysis techniques. They have had great success with external funding (they got 65% of what they requested on their new ARC grant) and have been particularly successful in federal grants for large equipment, which have been supplemented by the university[113] and industry (e.g., DeBeers).

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[110] E.g., Veal, D.A., et al, Fluorescence staining and flow cytometry for monitoring microbial cells, *J. Immunological Methods* 243 (2000) 191-210

[111] We had an interesting discussion about the relationship between CSIRO and the universities. This group expressed concern with regard to CSIRO's unwillingness to share its material -- the specific item of interest was a deep ocean black smoker -- particularly given its new thrust in BT.

[112] This Centre will combine their expertise in extremophiles, geology, and paleobiology, as well as space science and robotics. Although not of direct interest to ONR, this is an extremely active field internationally, which has been sparked in part by recent discoveries of very ancient microorganisms in rocks in western Australia, plus our rapidly expanding knowledge of the conditions under which life can exist. One target is the search for life on Mars and other extraterrestrial bodies; another is the origin of life.

[113] Macquarie has an internal grant procedure that provides 1-year support; they now accept applications continuously, and turn them around in 6 weeks. This new process helps their researchers with competition for external support.

CLA: Prof. James Piper directs the Centre for Lasers and Applications, and also is Head of the Division of Information and Communication Sciences in the Department of Physics. The Department has 12 core staff, an equal number of postdocs, and a declining number of graduate students, typical for the field. Prof Piper noted that with 4 physics departments in the Sydney area, each needed an 'identity', and Macquarie's is in optics and lasers. In addition to CLA, the Dept has a strong undergraduate program in optoelectronics which serves the Australian photonics industry (which grew out of an early CRC), and a good quantum optics group, and they do some work in astronomy. CLA was established in 1988, and had 9 years of support as a Special Research Centre followed by three years of bridging support by the University. It is now totally 'self-funded' via government competitive grants (it just received 4 ARC grants) and industry. CLA has 3 teaching and research staff, 10 research fellows and professional staff, and 11 graduate research students; its work is in 4 main areas: High Power UV-visible lasers (Prof Piper's particular expertise is in copper vapour lasers), solid state lasers, tunable lasers and applications in chemistry, and laser and optoelectronics applications (2000 annual report). They have a large and increasing number of projects with staff from other Macquarie departments, and both Australian and overseas universities.

Prof Piper described two aspects of their work that I found of particular interest. The first was kinetically-enhanced copper vapor lasers (via buffer doping to increase the relaxation speed, enabling them to increase rep rate and thus achieve an order of magnitude increase in total power and beam quality), for which a US patent was awarded at the start of 2001; this technology has been licensed to Oxford Lasers, Ltd, the major world manufacturer of copper vapor lasers. They have also demonstrated world record uv power levels from frequency-doubled CVLs. The second advance, of perhaps even greater interest for ONR, is the development of a diode-pumped Yb:YAB (a nonlinear, self-frequency-doubling laser crystal) solid state green laser with >1W CW power. CLA first grew this material, but it is now being produced for them via collaboration with Shantung University's Institute for Crystal Materials (PR China). This laser is of particular interest not only because of its power, but also because it is tunable (from 510-570 nm to date), and has excellent thermal properties so that it can be readily scaled up in output power. Lasers of this material should have many applications in marine sensing. CLA has also demonstrated inter-cavity Raman shifting and frequency doubling in solid state diode-pumped, Q-switched Nd:YAG lasers, yielding >1W output in the yellow spectral region. These and several other developments described by Prof Piper would appear to be sufficiently unique and of enough naval importance to justify a more thorough investigation by an ONR scientist with expertise in the field.

Cognitive Science and Sociology: My last session at Macquarie was with Profs Max Coltheart, Director of the new Center for Cognitive Science (a Special Research Center -- meaning research [and graduate education] only), and Anna Yeatman, an "interdisciplinary political theorist" (intellectual biography) and Prof of Sociology. Most of our discussion focused on the structure, and good and bad points about federal S&T support, and their views will be reflected in my observations about the Australian innovation system. Basically, however, while the ARC process is improving to help compensate for some overall deficiencies in the education/research system, there is a lack of systemic thinking about how to sustain national research efforts, and no S&T policy and strategy research unit in either government or academia. Prof. Coltheart is full time Director of the new SRC, and just received one of the new Federation Fellowships (US level salary or five years - designed to retain their superior talent, and attract back some from verseas); four faculty members are also in the Centre, along with 10 postdocs and 18 postgraduate students. While its charter is extremely broad, it will focus on psycholinguistics, visual cognition (selective attention) and monothematic delusions.

MARC: The Motorola Australia Research Centre is part (60 researchers, 80% with PhDs, of a total of about 120 staff) of the Motorola Technology Centre located in Botany, NSW (southeast

Sydney)[114]. It was established in 1995 as part of an offset agreement, and they stay because of the availability of highly educated people and their quality research output. Their brochure states that their mission is to "develop new, advanced technologies…leveraging Australia's strengths in speech and video processing and coding communications signal processing, multimedia telecommunications and internet technology…engage the Australian research and education sector and leverage the unique local environment to increase the scope and effectiveness of MARC's research…engage the region…with global business impact for Motorola". MARC has research labs for speech recognition, multimedia technologies for mobile internet and radio terminals, interconnection of devices via the public internet (networking and deployment of internet-aware devices), and image and video processing. Technology they develop is exported to Motorola Hq, then deployed where needed throughout the company. Motorola also has started to look at licensing its technologies outside, largely for equity interest and to open up new markets.

I asked to meet MARC Director Dr Peter Beadle both to get input on commercial IT R&D in Australia, and because he is on an ARC panel and thus could provide an industrialist's perspective on federal S&T; I will incorporate many of his comments in my forthcoming overview. Dr Beadle was quite positive about the leverage provided by the CRC's[115] , and Motorola is involved in two. The first is the CRC for Microtechnology which works on VLSI design and technology, multifunction device integration, microfabrication, and design and implementation of microdevices for biotech applications (e.g., integrated environmental sensing on a chip). This CRC, which is headquartered in Melbourne, has eleven members[116] and is funded at the level of $67M over 7 years. The second, which Dr Breadle was instrumental in founding, is the CRC for Smart Internet Technology. In addition to the intrinsic value of its technology (directly in line with MARC's mission), the CRC is expected to develop spinoffs in which they can take an equity position, and trained staff they can hire. Its core research areas are natural adaptive user interfaces, smart personal assistant, intelligent environments, smart networks, and user environments; and it will develop Demonstrator Projects that have been identified by the core industrial partners. This CRC has 11 core and 10 supporting partners[117], and is funded at $122M over 7 years; it should employ some 100 staff, generate about the same number of PhDs, and train about 100 MS students per year. Motorola's costs for participation are $200K in cash and $200K in kind per year. Great leverage!

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[114] My hoist Dr Beadle noted that Motorola's headquarters near Chicago is a hard place to which to attract PhDs. Given the importance of globalization, and that fact that most of their income derives from outside the US, Motorola has research operations in Australia, Paris, Tokyo, and Shanghai (for Chinese language research). These labs are to be distinguished from the Technology Centers of the Global Software Group (such as the new one going in at UWA) that employ 4-5K software engineers literally around the planet…anywhere there's a skill base, and often placed as a 'sweetener' or offset associated with a sale. The Botany lab itself was an offset for the sale of a public safety radio system to NSW; the Software Technology Center in SA was likewise an offset, and the one in WA was based on their need for additional talent, plus the 'good deal' they got from WA.

[115] Also the Linkage Grants, where they get about a 3:1 leverage, good but less than the CRCs. Motorola is involved in about a dozen of these.

[116] Alcatel, Bioproperties (Aust) Pty Ltd, Bosch, CSIRO, Australian DOD, Griffith Univ, Motorola, RMIT Univ, Strategic Industry Research Foundation, Swinburne Univ of Technology, the Queensland Government, and Vet Bioresearch Australia, Ltd

[117] Core partners are Adacel, CSC, Hewlett Packard, Motorola, Nortel Networks, Telstra, NSW Dept of Information and Technology Management, UNSW, Univ of Wollongong, ANU, and USydney; Supporting partners are the ACT Government, Australian Stock Exchange, Commsecure, Creative Digital Technology, QLD Cotton, WinTV, Adelaide Univ, Griffith Univ, RMIT, and Swinburne Univ.

Overall, Dr Beadle felt that Australia has good expertise in BT, internet software and services, remote sensing, and photonics[118]. It is somewhat weak in natural language processing and speech recognition. Its IPR system is satisfactory, with patenting regulations similar to those of the EU (first to file vs first to invent). Given market size, universities and companies typically do an Australian provisional filing, followed by filing in the US and Europe. One weakness in Australia is the lack of a strong manufacturing sector, largely due to labor costs and previous government protectionist policies (getting better). Because of relative strengths, many companies do research in Australia, manufacturing, packaging and distribution in Asia, and marketing and sales on the west coast of the US.

E. Canberra Observations, general comments

Canberra is a pleasant city, low key for a capital, and easy to get around (but for parking). I was accompanied on all visits from Monday through Thursday by Dr. Miriam Baltuck, the new S&T Advisor at the US Embassy[119]. We were able to visit with the leadership of most of the federal S&T agencies (ARC, NHMRC, CSIRO, DSTO, AGSO, DISR), of DOD (Deputy SecDef, Chief of Navy, DMO), and of the medical research and disaster management community (EMA, Health and Aged Care, and John Curtin School of Medical research); to interact with the committee that is developing Australia's space strategy; and to meet with the US DCM, ODC, and ALUSNA to discuss ONR interests. We also attended the dinner for the Prime Minister's Prize for Science, which let us see the peak of Australian S&T at its black-tie best. I was then able to spend Friday morning at the Australian National University, and also meet with two industry groups.

Altogether it was a very full and worthwhile week. Basically, Canberra's S&T performers reinforced my opinions about the value of Australian research. The discussions with Commonwealth Federal leaders added a new dimension to my perceptions, however. I now recognize that the job here for ONR will be less one of finding opportunities, than of complementing strategic and operational ties with an increasingly close ally. What I hadn't perceived is that there now is a strong parallel between our interactions in the UK (and to a degree Tokyo), and those here; namely, that our continuous presence is needed (both by us and by our hosts) not just for the sake of maximizing our interaction with students, academics and industry to leverage our S&T investments, but also to participate with this nation in the definition and implementation of the directions of development for future national security systems. I anticipate, for example, joint funding with DSTO and CSIRO of S&T projects (see the visits section, also reports on Melbourne etc), and considerable effort to define paths of development and experimentation leading to next generation systems, starting with submarines. I view this as a very positive development, and strongly in line with our recommendations to establish an Australian presence.

I will try to report separately and in some detail on my impressions about Australia's organization and strategy for S&T; for this report, suffice it to say that the federal government fully

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[118] The Australian photonics industry was generated from one of the first CRC's, initiated by OTC and Telstra with researchers from several universities. This CRC is now in its second round, and has generated a half dozen spin off companies that do about $2B worth of business. It is one of the major CRC success stories.

[119] For the past 4 years, Dr Baltuck, whose PhD is in marine geology from SIO, has been the NASA Senior Representative in Australia. She is extremely well acquainted with the Australian S&T community. Her new position is the first of its kind; she is seconded to the Embassy by NASA, and supplements the EST Officer by providing S&T advice to the Ambassador and country team, and assisting US agencies with their Australian S&T interests.

appreciates the importance of S&T for its future economy, has instituted a number of innovative new programs, and has committed to doubling the ARC budget over the next 5 years (part of the 'Backing Australia's Ability' program -- they're big on slogans); DSTO is also getting a budget increase, albeit not of the same magnitude. They have also done a credible job of assessing their strengths, weaknesses, and missed opportunities, and are preparing themselves to play a significant global role in both commercial and defence sectors in next generation fundamental technologies. And, their S&T management approaches -- which favor joint funding through clusters and centers -- offer significant opportunities for ONR to leverage their investments, as well as to continue to work with key individual investigators and labs in universities, government, and industry.

As noted above, my visits to researchers in Canberra reinforced yet again the impressions I gained in Perth and Sydney, namely that there is a very large amount of very high quality S&T in Australia. Australia has sponsored international reviews that have determined that a significant percentage of their research is world class, and I find no reason to disagree; indeed, even some projects that may not be world leading, are sufficiently different in approach from work in the US (and are done in conjunction with researchers in places we find hard to reach), that they are worthy of our close attention. Again, my discussions with senior DOD and RAN representatives likewise strengthened my opinion that commensurate with our evolving relationship in submarine matters, and the expansion of those strategic ties to other naval and defence matters, it is strongly in the US national interest to collaborate closely with Australia in both S&T and other aspects of the defence R&D and acquisition process. We have mutually reinforcing strengths as well as common strategic and system interests. Ties are already close, much as with the UK, which to my mind simply reinforces the importance of continuity and depth in our S&T interactions, meaning continuous presence as opposed to those occasional visits which characterize our interactions with less close countries. To reiterate, our task will be less one of discovery and persuasion, than in depth deliberation about technical options, and collaborative development of program strategies and plans. That can not be done from a distance, as a part time exercise. Thus I am more convinced than ever that it is important for ONR to have an IFO representative with expertise in ship technologies, stationed in Melbourne.

On the other hand, given Dr Baltuck's new position, her abilities and connections, and the fact that during this trip I will have visited many of the top institutions and S&T leaders across the country, there is no immediate need for someone from ONR in Canberra. I feel certain that our relationships will evolve to the point that we will want to broaden the capabilities of any ONR Australian presence, and indeed Canberra as the capital is the logical location for interaction with decision makers; but such broadening should be a matter for discussion at OSD as well as Navy, since it will likely involve both skills and programmatic procedures that are not in ONR's portfolio.

Finally, although the ACT is very small compared to the other states and territories, it has significant S&T activity of its own. Three universities (especially ANU), the military college, CSIRO laboratories, and several SMEs all have world class research activities. Our interest in Canberra may center upon the federal government and associated policies and strategies, but ACT has S&T resources that themselves warrant our review and support.

F. Canberra Visits. Dr Baltuck was with me during most of my visits, one of my principal contacts at ANU is already funded by ONR, and many of my visits were oriented more toward understanding S&T investment strategy and sponsorship (discussed elsewhere) than to actual research, so I will try to keep these comments brief, and in three sections: federal sponsorship and

management agencies, emergency management and health (of interest because of their prominent place in CINCPAC's engagement strategy), and actual research performers.

Federal Sponsors and Managers

ARC: The Australian Research Council has been Australia's principal university research funding agency since 1988 (NHRMC is the parallel agency for medical research - see below). Its role is roughly similar to that of our NSF, albeit its scope is even broader, including humanities and creative arts. Under legislation passed in July this year, ARC became an Independent Agency with a Chief Executive Officer, Prof. Vicki Sara, reporting to the Minister of Education, Training, and Youth Activities[120] and responsible for its own finances and administration, and management of the university component of the national innovation program. Under its new mandate, ARC has two primary roles: 'Discovery', i.e. to ensure a broad foundation of high quality world class research in the nation through a competitive, peer reviewed grant system, and 'Linkage', encouraging cooperative approaches to research by strengthening links within Australia's innovation system, and internationally. A large number of previous programs have been consolidated under these two headings[121]. ARC also is responsible for advising the government on research in universities, and both has its own policy section and sponsors studies of research issues and outcomes[122]. Commensurate with its new responsibilities and independence, ARC has changed its structure, and now has 6 disciplinary 'clusters', each headed by a Professorial level manager (seconded for 3-year terms from CSIRO or the universities) . The intent is to professionalize management of the research programs, and both increase the linkage to the researchers and improve relationships with other performing organizations. In addition to these structural changes (all of which were highly commended by many of the researchers I have talked to), the government has established several new programs to stimulate science and innovation, and committed to doubling ARC's funding, from today's A$270M to A$540M by 2005-6[123], under the "Backing Australia's Ability" plan[124]. As Prof Sara stated, at

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[120] Previously it was one of seven councils in DETYA, and Prof Sara was the Chair. The new legislation considerably strengthens the organization and positions it to take a proactive role in the nation's innovation system, and be a 'broker' for research, especially with other participants in the Australian system, instead of being simply a 'mailbox for grants'.

[121] The main program is grants to individual researchers; individuals can now have only two ARC grants at any time (but were allowed to 'roll up' smaller previous grants), but the length of grants has been extended to 3-5 years. ARC is also responsible for Special and Key Centres; CRC's are separately funded by the Department of Industry, Science and Resources, and selected by a committee on which ARC's CEO sits.

[122] Examples include *Research in the National Interest: Commercializing University Research in Australia*, 1998; and -- with CSIRO -- *Investing in our Future: The link between Australian Patenting and Basic Science*, 2000. Such studies were very important in convincing the government that research was critically important to the economy.

[123] Some of the more cynical faculty I have met note that this puts them back about where they started under this government, that cut universities by 20% as one of its first acts some 5+ years ago. They also note that government has a tendency to take away money that has few strings, then put it back in politically inspired, targeted programs.

[124] Other measures in this 5-year, $3B package -- on top of current government spending of about $4.5B for "innovation" -- include R&D tax concessions, industrial R&D "START" grants, increased funding for university research infrastructure, new world-class centres of excellence in ICT and BT, an expanded CRC program, doubled funds to support early commercialization, competitive pre-seed funding, further strengthening the IPR system, funding 2000 additional university places, loans for PG studies, increased secondary school standards, and a new Foundation Fellowship program (US-level salaries for five years) to retain and attract back from overseas, some of their eminent researchers (up to 125 over the next five years; 5/year can be from anywhere, and the other 20 are for Australians in the country).

last S&T is on the government's radar screen, and now they must move forward to think about strategy, policy, and setting priorities.

NHMRC: The National Health and Medical Research Committee was first constituted in 1936, and was the subject of an Act updating its structure (like ARC, it also has a CEO) in 1992. It is a statutory body under the Minister for Health and Aged Care, responsible for advising the Commonwealth and state governments on health, disease, heath care, and ethical issues related to health, and for recommending expenditures on research and training. It functions through four primary committees: Health Advisory, Australian Health Ethics, Research, and Strategic Research (about 1-2% of the total research funds[125]). All together, there are about 70-80 subcommittees and working groups under these, that involve over 500 individuals, sitting for over 260 days a year. In addition, there are about 20, 10-12 member disciplinary panels that recommend research grant recipients, based on written comments by referees (3 per application, and the applicants can comment on the critiques)[126]. The CEO Prof Pettigrew was extremely proud of the rigor of their peer review system, although he noted that is a very time consuming and expensive process. He also stated that although their funding was to double from the 1999-2000 level, the general attitude is that the increase simply makes up for previous underfunding.

CSIRO: The 75 year old Commonwealth Scientific and Industrial Research Organization is one of the largest and most diverse government research organizations in the world, with a staff of over 6000, including some 1800 PhDs. It has 21[127] sectors, labs and facilities all around the country, and 700 international projects with over 70 countries, plus a complex web of interactions with Australian universities and industry. Its work is of indisputably high caliber, and its people are very good - it was rated in the world's top 1% of research institutions in eleven of its sectors, and I have heard nothing but praise in the country for its quality. At issue, however, is organization's breadth, and its fundamental purpose in the Australian innovation scheme. It is extremely big and broad, and as an independent statutory authority, it does not directly respond to the needs of 'mission' agencies (in the way, for example, DSTO responds to its customer, DOD and the military services). It is being challenged to generate more of its own income, and to partner better with industry, while maintaining its intellectual base for long term benefits to the nation; but in some ways these mandates are (in my view at least) inherently in conflict. The nature of its strategic partnerships, as well as its priorities, are thus in question. While there is a "Strategic Plan" for each of the sectors, the dynamic new Chief Executive, Geoff Garrett (previous Director of CSIR in South Africa) has many challenges to face. It is interesting to note that substantial increases in CSIRO funding were NOT part of the 'Backing Australia's Ability' plan. This does not, however, mean that CSIRO does not offer excellent opportunities for ONR; indeed, they will if anything be even more interested in international collaborations in the future, and I regret not being able to visit more than three or four of their world class labs.

DMO: With 8000 staff, the Defence Materiel Organization[128] is responsible for 60% of Australia's defence expenditure. It is moving from an era of a significant number of mistakes and

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[125] Priorities include chronic disease, aging, and indigenous, mental, and oral health; each has different needs and programs.

[126] Success rate is about 20-25%, and grants are generally funded at about 70-80% of requests. Average grant size, which is increasing, is $112K.

[127] Atmospheric, marine, land and water, entomology, sustainable ecosystems, and the Australian Telescope National Facility; energy, exploration and mining, minerals, and petroleum resources; building, construction and engineering; health sciences and nutrition; food science, livestock industries, forest and forest products, and plant industry; manufacturing S&T, math & information sciences, molecular science, telecommunications and industrial physics, and textile and fibre technology.

[128] Recently created by a merger of the Support Command and Defence Acquisition Organization

associated criticism[129], into one of an average increase of 3%/year over the coming decade, and some very major procurements -- including replacement of much of the fleet -- in accordance with the new Defence Capability Plan (DCP 2001). These increases offer both an opportunity and a challenge. To quote Mick Roche, the Undersecretary of Defence Materiel, "the positive outlook for defence industry must be weighed against the fact that Australia represents approximately 1% of total global defence procurement expenditure. Clearly, self-sufficiency for Australia is not feasible. Defence industry must look closely for opportunities in niche markets, export markets, and becoming part of global supply chains is we are to have sustainable capabilities"[130].

Australia's approach to these issues was outlined in Minister for Defence Peter Reith's speech to the Defence National Procurement Conference on 26 June 2001, where he quoted last December's white paper, "we must take a strategic approach to our defence industry base, and not regard its capabilities as simply a by product of procurement decisions". Essentially, this means linking acquisition projects together strategically, industry rationalization[131], and becoming part of the global supply chain. The minister made seven points about this 'new strategic approach; these include recognition that DOD is a monopsony (THE marketplace, not a neutral player in it), and must define what key critical defence capabilities it needs[132]. Projects must be packaged to create a climate for sustainable industry, but primes must rationalize and or specialize, and international firms and DSTO both must nurture Australian SMEs. The envisioned environment will entail more 'alliance' contracting based on an 'open book' approach with primes, with open competition at tier 2. Government does not intend to pick winners, but expects industry players to rationalize themselves, preferably to the minimum number of primes they can support, "provided they are respected for their integration capacity and are able to access IP from overseas as well as in the country".

DSTO: The new industry and acquisition strategy will of course have significant impact upon the Defence Science and Technology Organization. Its head, the Chief Defence Scientist Dr Ian Chessel, has joined the PM's Science, Engineering and Innovation Council, and is accountable to the Defence Capability Investment Committee for the soundness of the technology involved in new acquisitions. DSTO will undoubtedly play a significant role in helping define the critical capabilities for Australian industry, and in developing those capabilities by transferring its own technology as well as nurturing S&T in SMEs. DSTO is under pressure to engage a wider community, and in doing so to consider the effect of its decisions on the relationships with the US. While one driving factor is life extension of existing platforms, another is definition of the technologies to be incorporated in the next generation fleet; and this will involve a heavy emphasis upon experimentation in advance of final decisions regarding system performance and characteristics. This sentiment was clear not only in discussions with Dr Chessel, but also earlier at DSTO Stirling, and in my meeting with VADM Shackleton. Driven by the White Paper

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[129] Minister Reith's June 2001 speech (discussed further below) cites the Collins Class subs and Jorn radar as large procurement projects where they gave little thought to how to sustain defence industrial capabilities after the projects were finished, and notes "neither defence nor industry thinks they work well together".

[130] *On Target*, DMO news bulletin, No20, July 2001

[131] He cited Australia's three major shipbuilders as an example of where Australia has failed to rationalize. In spite of the planned building programs, there is nowhere near enough upcoming business to keep them all operating; the sale of ASC is seen as an opportunity for industry to rationalize Australian shipbuilding..

[132] DCP2001 stressed 'the Knowledge Edge', and associated Tier 1 capabilities are combat and systems software and support; data management and signal processing; C3 systems; systems integration; and repair, maintenance and upgrade of major weapons and surveillance platforms. Further, it is essential that Australia have access to the source codes that determine the performance of their platforms. DMO is tasked to develop this list into specific industrial capabilities, with cooperation from Defence industry.

commitments, hard decisions will have to be made in a very few years; and there is therefore considerable urgency in sorting out alternative technological paths, through a combination of S&T and experimentation. Exemplary areas we discussed were electric propulsion, combat systems, minimization of life cycle costs, human cognition and training, and collaborative employment of 'virtual' ships and subs in exercises. VADM Shackleton noted that he is pleased with the new arrangements with DSTO, and would like to see ONR's increased interactions designed to minimize the impact of personalities and ensure transparency to the services. He, Dr. Chessel and Dr. Brabin-Smith all anticipate increased globalization and cooperation in the post-11 September environment, and stressed the importance of S&T in enhancing our capability to deal with asymmetric threats.

AGSO Geoscience Australia was formed from the recent merger of the Australian Geological Survey Organization (AGSO) and AUSLIG, the Australian Land Information Group. It has four major areas of research and survey, the three from AGSO being Oceans and Coasts, Rural and Regional (minerals), and Geoscience and Urban Centers (risk assessment), plus AUSLIC's land survey. Our host Trevor Powell is Deputy CEO, and also heads the Petroleum and Marine Group. They run a 'pragmatically focused' research program, largely oriented to marketing opportunities to the oil and gas industry. Australia does have petroleum deposits but is not widely seen as a major area for exploration, so they have to work to attract capital and continue to maintain self-sufficiency. Much of their other current effort is directed toward establishing the case, under LOS, for an extended continental shelf. This includes their portion of Antarctica. The survey work has been completed, and they are now developing the case. They also respond to the National Oceans Office (which I will visit in Hobart, Tasmania), for whom one project is to develop acoustic technology for mapping bottom habitats.

Emergency Management and Health

DHS: We discussed the ADF's Health and Human Performance research with BG Wayne Ramsey and Capt Jenny Firman of Defense Health Services[133]. DHS has just published a research Master Plan, which states that their primary focus is prevention of injuries and illness, and their second is impact on operations. There are three key themes: developing force capability, sustainability, and capability advantage[134]. Most of their research is performed by Universities, or the Army Malaria Institute; DSTO is responsible for BW/CW, and also does much human factors research. Commensurate with their new framework, they have issued a tender for a "Center for Military and Veterans Health" which will act as a preferred provider and hub for their research; the 10 universities with strong medical programs are forming consortia to respond. There is already a similar center for mental health jointly supported by Defence and Veterans Affairs at the University of Melbourne. Capt Firman discussed a recent research project that examined the physical competencies required for clearance divers; this was inspired by

[133] DHS cares for active duty personnel only, and then largely in a military context; routine, family, and veteran care is the responsibility of other Departments. They are considering outsourcing their few small base hospitals.

[134] At the first two levels, program categories are: 1. *Breakthrough Activity - Preventing Injuries and Illness*, 1.1: Protection of personnel from injury, 1.2: protection of personnel from disease, 1.3 minimization of the decremental effects of systems on human performance; 2. *Improvement Activities - Supporting a Deployable Capability*, 2.1 Development of a deployable operational health capability, 2.2 physical and psychological preparation of personnel for deployment, 2.3 selection and training of operational and support personnel, 2.4 maintenance of physical and mental health and fitness of deployed personnel, 2.5, Evacuation, treatment and rehabilitation of ill and injured personnel; 3. *Maintenance Activities - Developing a capability edge*, 3.1 Enhancement of physical and mental performance in both the individual and groups, 3.2 Maximize total system performance through improved human-system integration.

interest in introducing females into this field, but found that the fitness standards were ad-hoc and that much of the training was counterproductive to the actual requirements of the job, leading to a very high injury rate. They will apply similar techniques to other military occupations. BG Ramsey noted that the ADF is responsible for providing emergency assistance when requested by EMA (see below), but there is not an effective research program in disaster medicine. He was leaving the next day to present a paper on this topic to the Asian Emergency Care and Defence Medicine Conference sponsored by Singapore.

EMA: Emergency Management Australia, formed in 1974, is an agency in the Department of Defence. Primary responsibility for the protection of life and property rests with state and territory governments, but the Commonwealth provides assistance when requested by them. Thus EMA's primary responsibilities are to provide education and training (through the Australian Emergency Management Institute at Mt Macedon, Victoria), and to formulate policy and plans, and coordinate federal support when requested (through headquarters in Canberra). Australia does not require a 'national disaster' to be proclaimed before the federal government responds; rather, local Defence Force Commanders can provide immediate assistance as needed, and for more widespread and major disasters, at the request of the state or territory EMA will seek resources and approval directly from the Minister of Defence and other Ministers as appropriate (albeit most resources of interest belong to DOD).

Over the past several years, EMA has moved from a response to a risk management strategy, and has developed a number of courses and manuals on Emergency Risk Management for local authorities. In addition to their national responsibilities, they work closely with other Asia-Pacific disaster organizations, e.g. SOPAC, ADPC, and ADRC, as well as the US COE in Hawaii. They noted that under the risk management approach, information is just one, and not necessarily the most important aspect of planning, so that GDIN (as promoted by the US) is not a high priority[135]. My hosts stated that their responsibilities are getting 'broader by the day', and that since 1996 the National Emergency Management Committee has been developing a National Framework for Disaster Prevention and Mitigation that "aims to facilitate and support implementation of disaster prevention by all Australians, by all sectors, community groups and individuals" (brochure). They noted that natural disasters are 'reasonably well catered for', and it's the new threats, from human activity in particular but also things like infectious diseases (e.g., foot and mouth disease) that are the focus of attention. They are developing plans to address these type of disasters. Disaster medicine and EID as an element of this planning, are the responsibility of the Department of Health and Aged Care.

John Curtin School of Medical Research, ANU: JCSMR, a part of the Institute of Advanced Studies of ANU (meaning they do no undergraduate teaching - see below) has an outstanding international reputation with a long history (and two Nobel laureates) in immunology and virology. While they are primarily supported by core funds, the get about a quarter of their income from grants from the NIH, Wellcome Trust, and similar international sponsors; and along with the rest of IAS, they have recently become eligible (ANU/IAS bought their way in) for participation in national research grant schemes. The Director, Dr Judith Whitworth, was formerly Commonwealth Chief Medical Officer, and we spent much of our visit discussing the good and bad aspects of Australian research funding; her views will be incorporated in my report on the Australian innovation system. JCSMR has a total staff of about 350, with 30-40 research group leaders. They train some 80 doctoral students, and have about 40 postdocs. We briefly discussed many areas of their research, from synaptic transmission to vaccine development to health problems associated with F111 life extension, that would be of interest to ONR 34. Also of interest to us, the Director has discussed with ADM Barrie, Chief Defence Staff, the possibility of providing graduate medical training for military personnel.

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[135] Their relatively negative take on GDIN mirrored the opinion of ADPC ; see report 6.

Research Performers:

ANU: ANU was established by the Australian Government just after WWII, to be the national centre for world class research (and postgraduate education). Undergraduate teaching was added in 1960, and in 1992 the Canberra Institute of the Arts was amalgamated with ANU. Given its initial charge, and a continuing mission to pursue research at the highest international level, ANU today has two principal components: the Institute of Advanced Studies, comprised of 10 Research Schools (like JCSMR, discussed above)[136], and six Faculties[137], plus the Institute of the Arts, and the usual complement of Centres. IAS research is supported by a block funding from DETYA, as part of the University's Commonwealth Government Operating grant. Research by members of the Faculties, where all the undergraduate (and some of the postgraduate) teaching is done, is obtained competitively from ARC or other sources, just like at the other Universities.[138] Recently, IAS 'bought-in' to the ARC grants scheme -- i.e., they paid the equivalent of the average success rate to be able to compete, with the proviso that they could win ±10% of that amount; not surprisingly, they hit their cap, which they expect to be lifted in coming years.

ANU is relatively small compared to the other top level Universities in the States (the Group of 8), with about 8200 undergraduates, and 2500 postgraduates. It also has somewhat more diversity than is typical of the others, reflecting a combination of the small population of ANT, the high standards for entry, and its international reputation; about 60% of the undergraduate students are from the ACT region, and 13% are international (30% postgraduate). IAS has about 470 academic staff, the Faculties 450, and the Centres an additional 100+. There is occasional, but minor, migration between IAS and the Faculties; they are probably moving, albeit very slowly, toward a more unified approach. I visited with the Academic Pro-Vice Chancellor, the Director of the Research School of Physical Science and Engineering (who at one point in his career worked for AFOSR), and one professor each from the Faculty and IAS.

Prof Hans Bachor is in the Physics Department which has 10 faculty, four of whom are purely teachers and the other six are funded competitively by ARC. This Department specializes in optics, particularly sensors, interferometry, and quantum optics. Prof Bachor commented that this is an area of considerable interest to the students (and national importance given Australia's photonics industry and its strong intent not to miss out, as it did with digital computers, in the next round of major IT advances) so that they have not suffered, while in general physics departments have lost about 25% of their students and comparable staff over the last few years[139] (he faults poor preparation at the secondary level). Prof Bachor's personal research is in quantum cryptography, entanglement (and thus 'teletransportation') -- for which he just received a 5-year ARC grant (one of the first new ones of that length) -- and investigating the possibility of quantum computing using light (he thinks it unlikely). He is also designing a new set of sensors for the international gravity wave detection experiment. The University recently built him a new state of the art, clean-room facility for his experiments; he is extremely well connected internationally, working on a par with the leading researchers in the US and Europe, and has several international postgraduate students and postdocs. Interestingly, he cited Herb Pilloff of

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[136] Biological Sciences; Chemistry; Earth Sciences; Information Sciences and Engineering; JCSMR; Pacific and Asian Studies; Physical Sciences and Engineering; Social Sciences; Astronomy and Astrophysics; and Resource and Environmental Studies

[137] Arts, Asian Studies, Economics and Commerce, Engineering and IT, Law, and Science

[138] As a reminder, teaching, facilities, and some research are also supported from the operating grant. ARC (and the CRC scheme) need support only the additional, 'direct' costs of research grants.

[139] DETYA has a formula for funding universities that counts student load. This was never intended to be applied below the institution level, but in most universities it is simply passed on to the individual Departments, it being 'too hard' to make the tough calls any other way.

ONR as the inspiration for his initial interest in squeezed light, which now forms the basis for his cryptography research.

I also visited with Prof Mandyam V. Srinivasan of the Research School for Biological Sciences, who is internationally renowned for his work in insect vision and its applications to robotics. Prof Srinivasan was the recent recipient of one of the new Federation Fellowships; in his case the fellowship met its objective of keeping him here in Australia, since he was about to go to UC Davis. I need not describe his research here since ONR (Joel Davis) along with China Lake, DARPA, and a host of other international sponsors have been funding him for several years. His work in biomimetic navigation and control is indeed of significant interest to the military as well as to industry; DSTO has a researcher stationed in his lab.

CEA: CEA Technologies Pty Limited is an R&D intensive Australian SME with about 150 employees and an annual turnover of ~$20M. I spent the afternoon at their Fyshwick facilities where they do most of their electronics design and signal processing development; they also have facilities in Melbourne and Adelaide. They work very closely with DSTO, and also with SPAWAR and other US agencies, and have a US owned company, CEA Technologies Inc. in San Diego to support their work in the US (among other projects, they built the modular integrated radar surveillance system for MIUWS; my DSTO contacts stated that they had sold other significant sensitive technology in the US). They cite their main expertise as radar and phased array radar technology, data fusion and advanced signal processing, active and specialized communications antennas, and communications and EW systems technology. I was extremely impressed with their S band phased array radar and X-band illuminator, also with their radar signal processing, and with their wide band antenna technology (same basic objectives as AMRFS - significantly reduce the number of antennas on Australian combatants and PBs - but much simpler).

Of particular interest, they have developed a processor that can extract general classification features of surface targets, and detect periscopes, from regular surface search radars. Australia is procuring these systems for their ANZACs and FFGs; the fast ferries are also interested, for collision avoidance in crowded littoral waters. Their periscope detection system was the subject of a Foreign Comparative Test Program via SPAWAR a couple years ago (this was before the other capabilities were built in to the processor), but it is apparently perceived as a competitor to ARPDD. I don't pretend to understand the details of performance, or the politics, but I strongly suggested that CEA pursue the topic with the ONR CTTO and the DSTO representative at their DC Embassy. In general, their systems are first rate, and worthy of further detailed evaluation in the US, particularly because they represent quite low cost, innovative and modular solutions to many of our capability requirements. Given VADM Shackleton's interest in AAW as a future area of close US-Australian collaboration, and CEA's phased array radar expertise, we should ensure that we take full advantage of their developments. This is another opportunity which deserves detailed follow-up by IFO.

PNC: Ranicar and Nicholls Consulting is a new firm that combines the skills of retired submariner David Nicholls (his last tour was three years of exchange duty with SUBPAC; he comes high commended by senior US submarine officers), and Dr Jeremy Ranicar, who had 23 years in DSTO, including two diplomatic postings in the UK, plus two years with Nautronix before setting up his own consulting firm. Both are extremely well connected and respected in Australian defence and industry circles, and were very helpful to me both in making contacts and in understanding Australia's policies and programmes. Depending upon decisions regarding ONR's posture in Australia, their consulting services could be very helpful.

G. Initial Conclusions and Recommendations

First, there is more than adequate world class S&T in Australia (even before I visit the rest of the country) to justify an ONR presence. The Australian funding system is ideally suited to collaborative and critical-mass-based research, the scientists are comfortable with the US and Europe, and there are no perceptible prejudices against working for a Defence organization, or for an international sponsor. From a purely US perspective, the leverage we could obtain would in itself more than pay back our costs. The hit & miss (mostly miss) coverage we have had through TDY visits is not commensurate with the resources available to be tapped.

Perhaps more importantly, as I have already stated, I believe -- based on my interactions with senior Australian Government representatives, combined with my other visits -- that ONR S&T collaboration is strategically, as well as tactically, desirable for the US. The Australians are in the process of making major changes in their innovation and acquisition systems, and together with the new commitments under DCP 2001 and Backing Australia's Ability (among others), the time is right for close interaction on defining technological directions for our future forces. We already develop and train together, to a considerable and increasing degree. Our strategic operational and system relationships are expanding, and will mature best if underpinned by close interaction in S&T, since technology supports both economic security and -- as both nations have included in their Defence strategies -- the knowledge and technological edge required for national military security, against both conventional and asymmetric threats. I can not envision establishing the close relationships both nations desire for their naval forces, absent the sort of S&T collaboration that ONR can bring. And, as I stated in the body of this report, as with our other close allies like the UK, this means continuous interaction, not the short-visit, relatively casual attention accorded our less close partners. London (and to an extent Tokyo and Singapore) should be the model for the sort of presence we would like eventually to establish here.

With regard to recommendations, let me first suggest that the IFO read in detail my visit notes, and discuss specific opportunities with me when I return. Identifying 'hot items' was not the intent of my trip, but there are enough here that I have found without half trying, that they should be pursued. Further, there are some opportunities that our CTTO should address -- e.g., with CEA Technologies. A DeCorpo visit, assisted with targeting that our consultant contacts can provide, is certainly in order; there are some available industrial technologies that we should move on immediately.

Thus my primary recommendation at this point is to resubmit the NSDD-38[140] to send an ONR ships technology expert[141] to Melbourne, to work closely with RAN and DSTO as they define the requirements for their next generation platforms and systems, and develop their experimental program for the next several years, which will lead to the final system characteristics. Although S&T is by its very nature a long term process, there is some urgency to this given their schedule. Further, this action has already been delayed about a year from the time we envisioned it would be desirable, and expeditiousness would be perceived as an appropriate response to the Australians' desire for us to establish this office.

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[140] Assuming we need one. We have had many conflicting statements about this over the last year; the latest, from Col Opel the ODC, indicates that one is required. While I have no doubts that he is now providing us his best advice at this time, the number and degree of conflicts indicates to me that we should seek official confirmation from the Department of State. Irrespective of this formality, however, close coordination with the Embassy in Canberra is in order.

[141] In visits with DSTO and later in Melbourne - see Report 9 - I confirmed that Dr Peter Majumdar is an ideal selection, given his expertise in propulsors, acoustics, hydrodynamics, and other aspects of ship technologies. He is very highly respected by the Australians, and they were adamant in confirming that they strongly desire to have him working with them.

ONR had also asked to post a second individual (me, in fact) to Canberra as part of our initial NSDD-38. I do not now believe that is needed at this time. Dr Miriam Baltuck, if appropriately supported financially and with information by ONR, and permitted by the country team (and DOS and NASA) to assist us, can do a much better job than I in following Australia's S&T policy, strategy, and investment initiatives, and in relating them to our interests. At the same time, she can serve similar needs of other US mission agencies, should they desire to take advantage of her considerable talents. Given her research and managerial background, she also possess expertise and superb credentials in ocean, atmospheric and space research, which alleviates the need for one of ONR's (and my own) specialties to either frequently visit TDY or be stationed in the country. Indeed, my sense is that she is fully capable of overseeing both our corporate interests, and the specialties in which she has been educated and practiced -- even better than our own team.

Although I have not yet visited DSTO or CSIRO labs (those visits are yet to come), and I want not to be too anticipatory in these reports, I expect -- based on conversations with their senior representatives in Canberra -- that we may want to establish the same sort of cooperative agreement with either or both of them that we have had with UK MOD for several years, and recently started with Singapore; namely, annual meetings of leadership (e.g., between Australia's CDS and ONR's TD) to define, initiate and review cooperative projects. I have already noted that Australia's CRC scheme is ideal for this purpose, and enables us to work both directly with their federal labs and with their universities and academics simultaneously. Some projects we may even wish to make trilateral[142]. I will have more to say on this point after my next set of visits, but want to note at this point that the success of any such arrangement will rest on the ability of the in-country ONR rep to maintain continuity and exercise appropriate oversight.

In sum then, I recommend we proceed to work with the country team to station Dr Majumdar in Melbourne, and support Dr Baltuck in her current position to serve the major portion of the rest of our immediate needs. As I will discuss in another report, I believe that these are just the initial, but appropriate, actions by ONR, and should precede discussions related, e.g., to the joint project arrangements mentioned above. Further, our agreement on submarine matters, together with other collaborations such as the Global Hawk tests and planned procurement, plus the implications from leadership that they desire an expanded collaboration in other capability areas, implies that we should rethink overall defence R&D and acquisition relationships with Australia. I am well aware that some of these issues (e.g. export licenses) have been in progress for some time, but others -- such as identification of critical technologies for indigenous capability, preferred technologies for collaboration, and releasability (including source code) will take some effort. Our IC relationships are already exceedingly close, and the evolution of Navy relationships needs to be factored into whatever we decide to do in a broader sense of defence acquisition relations. I will work these issues with DOS (and via them the country team), DOD, the Services, and other agencies upon my return to the states; but we should not wait upon this, to start the S&T collaborations that we both recognize are in our mutual best interest.

As a final caveat, I feel certain that the US Ambassador will need to be assured that the type of activity we envision can not be provided at lower cost through TDY. I have already stated my arguments that TDY is operationally and technically inappropriate for the sort of relationships that both USN and RAN wish to develop. Financially, since TDY support would come from Tokyo (or at a stretch, London), I can only note that the staff primarily responsible for our

[142] E.g., Dr. Nandagopal suggested that Australia would like to participate in the UK-US VON; I expect I will hear more about this when I visit Adelaide.

international interactions is already posted overseas, and Melbourne is certainly no more expensive that our other international stations. When those costs are added to the travel and TDY costs to Australia from England and Japan or Singapore, then the financial advantages of PCS to Australia should be clear. An occasional touch & go may be cheaper by TDY; but the sort of intensive interaction that I believe necessary is definitely not.

Itinerary: Perth, Sydney, Canberra

12 September, Wednesday: ~1430 Arrive from Delhi/Singapore RON Freemantle Esplanade

13 September, Thursday: AM (1) DSTO Stirling; Dr Chris Davis, Head, Sub Ops Research (Chris.Davis@dsto.defence.gov.au; +61 8 953 3594)
(2): Nautronix, 108 Marine Terrace, Freemantle; Ross Stuart, Director (ross.stuart@nautronix.com.au; +61 8 9430 5900); Stephen John
PM: Curtin University of Technology; Prof Paul Rossiter, Deputy Vice Chancellor for R&D (p.rossiter@cc.curtin.edu.au; +61 8 9266 3045); Prof Brian O'Connor, Head, School of Applied Science (toconnorb@cc.curtin.edu.au; +61 89266 7510)
Curtin Centre for Marine Science and Technology, Prof John Penrose, Director, & staff (J.Penrose@cmst.curtin.edu.au; +61 8 9266 7380)

14 September, Friday: AM: Roundtable hosted by William Erb, IOC Perth Regional Office (w.erb@bom.ov.au; +61 8 9226 2899) and John D. O'Hare, Marine & Defence Team, Western Australia Department of Industry and Technology (jooh@commerce.wa.gov.au; +61 8 9327 559) (w/reps from Bureau of Meteorology, CSIRO, WNI Oceanographers & Meteorologists, Sverdrup Technology, Curtin Remote Sensing & Satellite Research Group, & Murray-Darling Basin Commission)
PM: University of Western Australia: Prof Michael Barber, Pro Vice-Chancellor (Research and Innovation), mbarber@acs.uwa.edu.au; +61 8 9380 2460) with Profs Syd Hall (crystallography; semantic web), Beverly Ronalds (offshore structures), Lorenzo Faraone (EE), David Braddock and D.Morrison (Psychology), and Charitha Pattiaratchi & Jorg Imberger (Centre for Water Research); also Motorola Australia Software Center, Richard Burford, Managing Director (Richard.Burford@motorola.com, +61 8 8168 3501)
Dinner: Eva Marjanovic w/ Prof & Mrs Penrose

15-16 September, Sat & Sun: Visit SW Corner; RON Pemberton Saturday, Perth Sunday

17-19 September, Monday-Wednesday: Train, Perth-Sydney

20 September, Thursday: Arrive Sydney ~1015; RON Park Regis
AM: ADOC: Ben Searle, Director
PM: University of Sydney; Prof. Less Field, Acting Pro Vice-Chancellor (Research) (lfield@vcc.usyd.edu.au; +61 02 9351 4138); Dr Salah Sukkarieh, for Assoc Prof Hugh Durrant-Whyte, Australian (Key) Centre for Field Robotics (salah@acfr.usyd.edu.au, +61 2 9351 8154; http://www.acfr.usyd.edu.au)
Evening: Paul Scully-Power, Board Member, AusTrade; Chairman, Australia Fund (psp@australiafund.com.au, +61 2 9221 1554 cell 0419 777 462)

21 September, Friday: AM: Macquarie University, Prof Peter Bergquist, Deputy Vice Chancellor, Research & Prof of Biology (peter.bergquist@mq.edu.au; +61 2 9850 8645); Prof Trevor Tansley, Dean of Graduate Studies, Research Office (Trevor.tansley@mq.edu.au; +61 2 9850 7986); faculty: Dr Michael Gillings, Senior Lecturer, Key Center for Biodiversity and Bioresources; Dr. Paul Attfield, Team Leader Microbiology Applications, Australian Flow Cytometry Group; Suzanne O'Reilly, Prof of Geology and Director, GEMOC National Key Centre; Dr Malcolm Walter, Adjunct Prof & Director, Australian Centre for Astrobiology; William Griffin, Adjunct Prof &

Senior Principal Research Scientist, CSIRO; James Austin, Prof of Physics & Director, Centre for Lasers and Applications; Max Colthart, Director, Macquarie (Special) Centre for Cognitive Science, Prof of Psychology; Anna Yeatman, Prof of Sociology
PM: Motorola Australia Research Center, Dr Peter Beadle, Director (Peter.Beadle@motorola.com; +61 2 9666 0693); RON Kiama

22 September, Saturday: Transit to Canberra via Jamberoo & Moss Vale; Barren Grounds Bird Observatory; RON Canberra, Bentley Suites

23 September, Sunday: Report preparation; Tidbinbille Ecology Reserve

24 September, Monday: Host for the week Dr Miriam Baltuck.
AM: Report preparation; Defence Health Services, BG Wayne Ramsey DG, DHS; wayne.ramsey@cbr.defence.gov.au; 2 6266 3919) & Capt Jenny Firman (Director, Preventive Health; jenny.firman@cbr.defence.gi.au; 2 6266 3831).
PM: Capt David Nicholls, Dr Jeremy Ranicar, RNC (dandlnic@hn.ozmail.com.au, 2 6282 1437; ranicar@bigpond.com, 2 6282 6947)

25 September, Tuesday: AM: (1) Emergency Management Australia; Rod McKinnon, Director Planning & Operationa (rmckinnon@ema.gov.au; 6266 5328); Jonathan Abrahams, Acting Director Development (jabrahams@ema.gov.au; 6266 5219); Rob Lee (rlee@ema.gov.au); 03 5431 5245)
(2) Defense Materiel Organization David Learmonth, Head Industry Division (6266 7489); Dr Paul Earnshaw, Director Scientific Support - Materiel (paul.earnshaw@defence.gov.au; 02 6265 1443)
PM: (1) CSIRO, Director Dr Geoffrey Garrett (geoff.garrett@exec.csiro.au; 6276 6766)
(2) Science Advisor to the Minister, Industry, Science and Resources, David Wawn
Evening: Dinner, Prime Minister's Prize for Science

26 September, Wednesday: AM: US Embassy, DCM Michael Owens, ODC Col Spethen Opel, Naval Attache Capt Daniel Sloss
PM: (1) Chief Defence Scientist Dr Ian Chessel; Deputy Secretary of Defence, Strategy, Dr R. Brabin-Smith; First Asst Secretary Science Policy Dr Roger Lough (who will relieve Bill Sutcliffe as head of AMRL at the end of October) (roger.lough@cbr.defence.gov.au, 2 6265 7919); Chief Maritime Operations Division, Dr Nanda Nandagopal, nanda.nandagopal@dsto.defence.ov.au; 8 8259 5163)
(2) Chief of Navy VADM David Shackleton AO RAN, ChiefofNavy@cbr.defence.gov.au; 2 6265 5162)
Evening: Dinner w/RCN (David Nicholls Jeremy Ranicar & wives)

27 September, Thursday: AM: (1) Dr. Vicki Sara, Chief Executive Officer, Australian Research Council (vicki.sara@arc.gov.au; 2 6284 6605); Helen Fullgrabe, Director, Operations and International, ARC (Helen.fullgrabe@arc.gov.au; 2 6284 5579)
(2) Space Strategy Advisory Panel, Chair Dr Paul Scully Power
(3) Mr. Peter Channels, Disaster Medicine Unit, Population Health Division, Health and Aged Care (peter.channels@health.gov.au; 2 6289 3763)
PM: (1) Dr Trevor Powell, Deputy CEO and Chief, Petroleum and Marine Division, AGSO Geoscience, Australia (trevor.powell@agso.gov.au; 2 6249 9471)
(2) Prof Judith Whitworth, Director, The John Curtin School of Medical Research, ANU (judith.whitworth@jcsmr.anu.edu.au; 2 6125 2597)
(3) Prof Alan Pettigrew, CEO National Health and Medical Research Council (alan.pettigrew@nhmrc.gov.au; 2 6289 9543)

28 September, Friday: AM: Australian National University. Prof Hans-A. Bachor, Photonics Program, Physics, Faculty of Science (Hans.Bachor@anu.edu.au; 2 6125 2747); Prof Mandyam Srinivasan, Director, Centre for Visual Sciences, Research School of Biological Sciences, Institute of Advanced Studies (m.srinivasan@anu.edu.au; 2 6125

2409); Prof Erich Weigold, Directory, Research School of Sciences and Engineering (Director.RSPSE@anu.edu.au; 2 6125 2476); Prof Robin Stanton, Pro Vice Chancellor, Academic Development and Information Services (pvc.academic@anu.edu.au; 2 6125 2504)

PM: CEA Technologies; Andy Anderson, R&D & Phased Array Program Manager (aka@cea.com.au; 2 6213 0066); Mark Foster, Marketing Manager (mf@cea.com.au; 2 6213 0001)

29 September, Saturday: Report Preparation; Floriade; City

30 September - 1 October, Sunday & Monday: Transit to Melbourne

Report 9: 1-21 October 2001: Australia Part 2: Melbourne, Tasmania, Adelaide
A. Melbourne Observations
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A. Melbourne Observations

Melbourne is quite a lovely city, once you get past the unpleasant surprise of the pass-only City Link freeway system[143]. Like Sydney, it is an intellectual as well as commercial center. Unlike this 'rival' however, its S&T institutions have very strong support from the State of Victoria. My host at DSTO left my briefing to attend the launching of a new Innovation Center, and upon his return recounted that the Premier's speech mentioned that Victoria does 50% of the nation's BT business, and 40% of its IT. In addition to the $100M Victoria put forward to win the new national synchrotron facility (to be located near Monash University), it has another $100M that it is using to stimulate innovation. Victoria and Queensland are the clear top competitors for leadership in the new technologies that the Commonwealth is promoting.

If the places that I visited are at all representative of the rest of Melbourne's S&T capability, then the State's competitiveness is indeed based on great strength. To the basic question I am addressing on this trip -- is there adequate S&T in Australia to justify an ONR presence -- my Melbourne experience again reinforced the conclusion I formed in Perth, Sydney, and Canberra, namely, overwhelmingly so. And, as in those other cases, my sampling was sparse if broad (as just one example, I didn't visit the University of Melbourne, one of their research leaders).

One particular strength of Melbourne for ONR's purposes is the presence of much of DSTO's AMRL. It is largely for this reason that we suggested that Dr Majumdar be stationed here. Although I have yet to visit Adelaide, where the most of the rest of AMRL and ESRL are located, I can state that I now agree that Melbourne is a very appropriate center for our technical activities and for detailed interactions with AMRL and RAN, as discussed in Report 8. One very clear message I received here is that they strongly desire our presence, both for the technical collaborations we can establish, and to help them work more efficiently with the US system as our relationships grow in strength and breadth[144]. Several AMRL leaders commented that when trying to interact with our Navy they spend 85% of their time simply trying to figure out who to talk with, so a senior ONR rep who not only has technical expertise to bring to the partnership but also is very familiar with NAVSEA and the Navy Warfare Centers, and with US procedures and

[143] Probably not a big deal if you're aware of it, but…as you drive toward the city, the signs on the freeway warn you to leave if you don't have a City Link pass, throwing you into the street maze of the suburbs. Once I figured the system out I was fine, but a visitor needs to be aware and plan ahead.
[144] The introduction to my visit that I give at all my stops in Australia includes that fact that our request to open an office here was turned down by our Ambassador, and I have therefore been asked by ONR to reassess our position. Several times I have been asked by my hosts what they can do to help. My response has been that if they do meet our Ambassador or other country team members, to simply note informally that it would be desirable to have an ONR rep in the country, if indeed that is what they believe. I should also mention that per ONRIFO policy, all my reports are public and web-suitable; indeed I have had to ask for help from several locations to send them out for distribution to ONR, so they are widely available.

regulations, could significantly expedite a very wide range of interactions. The same problem, and benefits of presence, pertain equally in the opposite direction, of course.

As I relate in my visit descriptions below, another common characteristic of Melbourne's researchers and S&T institutions, is that many are already very familiar with ONR. We have, for example, funded BMRC investigators rather consistently over the years, and they work closely with NRL Monterey. Because of that connection, we played a significant role in the early days of Aerosonde™, which was formed by a BOM scientist. The same goes for the Universities, CSIRO, and CRC. Even when we haven't already established a track record of support, they were familiar both with ONR, and with the IFO's programs, in particular NICOP (which I'm pleased to say has thereby served at least one of its initial purposes quite well). This degree of familiarity, and the associated openness with which ONR is welcomed, simply means that it will be very easy for us to establish the sort of close working relationships in S&T that I envision are called for by our evolving strategic partnership. Again, as I said in Report 8, my prior impression that we would need to do a lot of investigation to define opportunities has changed significantly, and I now believe that we need to think in terms of the same sort of close, enduring interactions that we have with the UK; indeed in many ways, the same sort of relationship that ONR has with our own NRL and university researchers, and Navy's Systems Commands and their Centers. Everything I saw in Melbourne reinforced this view.

B. Melbourne Visits

DSTO: Dr Peter Majumdar, whom we propose to station here, is very familiar with AMRL and its programs, so I will only very briefly describe the organization, then cover some of my discussions about ONR plans, and highlight a couple of S&T items that I found most impressive.

DSTO has two main subdivisions, Aeronautical and Maritime Research Laboratory, and Electronic and Surveillance Research Lab. I visited with the AMRL Director, Dr Bill Schofield (retiring at the end of October, to be replaced by Roger Lough), and his Air Operations and Airframes and Engines Divisions in Fishermans Bend, and the Maritime Platforms Division in Maribrynong. The latter site will be closed and all personnel transferred to Fishermans Bend over the next year or so. DSTO overall has about 1850+ staff (650 research scientists), of which 1000+ (355) are in AMRL; they will grow commensurate with the increase in the Defence budget, of which they get @2%. The labs' responsibilities comprise ops analysis, acquisition advice, warfighter support, and through-life support. Although the vast majority of their work is done on a quasi-contract basis with military customers with whom they negotiate aims, milestones, budgets and even staffing, the relationship is more one of partnership than customer-supplier, and the fact that their funds come directly does give them a powerful independent voice and considerable bargaining power. Most of their work is for Air Force, Navy, and the Joint command, with smaller amounts for policy, strategy, and the Army (the least technological service). In addition to the DOD DSTO budget, some 15-20% of their revenue comes directly from the Services.

Dr Schofield emphasized that Australia has little capacity to produce all-up weapon systems and so typically buys its major platforms from the US or UK. Therefore DSTO does S&T as opposed to R&D, and focuses on being world class in performance-determining capabilities appropriate to Australia geography, climate, and small population, e.g. sonar in warm, shallow seas, HF propagation and ionospheric characteristics in the southern hemisphere, and human factors. Ops analysis, M&S, and virtual environments are vitally important, and DSTO's advice to DOD (especially DepSecStrat) in recommending technical characteristics to meet capability requirements (in the 12 scenarios against which they measure performance) plays a major role in the decision process. Further, since they can not afford to replace systems as

frequently as the US, they have become expert (they lead the world) in fatigue testing and life extension; I saw impressive examples of their work on the F/A18, F111, and P3. They keep a 'payoff book' that demonstrates convincingly the ROI of their research.

We spent some time discussing the proposed assignment of Dr Majumdar from ONR to Melbourne. Dr Schofield and his staff were adamant that they attach great importance to this assignment, particularly given the US-Australian collaboration in submarines, which they expect will soon be extended to AAW and other surface ships, and thus have a significant impact on the future of their force structure and their defence industry. While they now do interact with ONR, the partnership they (and we) desire can only be achieved by much more continuous, broad, and intensive interaction. Dr Schofield also noted that DSTO has several research scientists in Washington, and at several Navy labs and Warfare Centers, and a comparable US presence at AMRL would enhance the mutual benefit of our interactions, and significantly improve communications. Such cooperation should save considerable time and money for both sides[145]. In addition to the broad advantages of having a US ship technologies expert in Melbourne, Dr. Majumdar's personal expertise in propulsors, acoustics, and hydrodynamics is particularly important at this time because of their need both for further Collins class improvements (e.g., maneuvering signatures), and for technological cooperation as they start to define characteristics for follow-on classes; both topics are of high interest to USN, and having someone on the inside in Australia would provide us invaluable information, and give us more opportunity to ensure that the long term US agenda for fleet compatibility and mutual reinforcement is met. Further, they noted, Dr Majumdar is already very familiar with the Australian programs and researchers, and highly respected by them, so he would need no 'startup' time. Interestingly, I heard similarly strong positive sentiments regarding his capabilities and possible assignment at the Melbourne CSIRO labs, CRC-ACS, RMIT, and Monash University, all of whom are to one degree or another currently involved with ONR, and very interested in closer technological collaboration for our mutual benefit.

I was particularly impressed with AMRL's work in materials, fatigue testing, environmental factor analysis, and M&S (including a new submarine hydrodynamics research project where Dr Majumdar's
advice would be very beneficial to both sides). Since many if not most Australian platforms and major weapon systems are of US manufacture, the vast majority of DSTO S&T is directly applicable to our own interests. From an environmental perspective, their work in corrosion and biofouling control, stewardship (control of invasive species in ballast water, MARPOL compliance, etc), and marine mammal and habitat interactions are as applicable to our own as to their operations in the south Pacific, Southern, and Indian Ocean waters, with which they are very familiar. Further, both USN and RAN are relying heavily upon experimentation with new technologies and operational concepts in order to refine future system characteristics, tactics, and doctrine, against both conventional and asymmetric threats. Continuous real-time linkage of our simulators and virtual platforms, to complement our at-sea exercises and joint training, should be a matter of high priority. Having someone on site here to assist with coordination and security arrangements would greatly expedite this connectivity.

CSIRO: I visited CSIRO's Divisions of Manufacturing S&T, and Molecular Science, which are located adjacent to Monash University's Clayton campus. As with several of my other

[145] To reiterate, they spend more of their time figuring out who to talk to, and what our rules are, than actually interacting. The presence of someone from the US who knows both sides very well, as does Dr Majumdar, could solve this problem for them and us. It is important to note that this task is much more than that of being a human telephone directory; what's needed is someone with technical, systems, and organizational knowledge, and the ability through personal contact and reputation to gain rapid access to decision makers both in the US and Australia..

Melbourne stops, Dr Majumdar had recently visited; they were in the process of developing pre-proposals for him to pass to ONR Hq. In his introduction, Dr Sare stated that CSIRO accounts for approximately 10% of the total R&D expenditure by performers in Australia[146], with revenue of $880M/yr (2/3 Government, 1/3 earned), and 6000 staff (4000 research)[147] (as one of my hosts said, it is sort of like a big research university without students). The Manufacturing S&T Division has 270 staff (down from 335 last year) with an income of $44.5M, of which $12.8M is external. Their principle site is in Melbourne, with joining work in Adelaide and some equipment automation and light metals research in Brisbane. Their capabilities include manufacturing processes (welding, casting, forging, and micro-manufacturing [e.g., optically variable devices for currency security]), sensing, measurement, and control (machine vision and automation, x-ray imaging), integrated manufacturing systems (modeling, robotics), and materials technology (materials characterization, alloy development, breathable and biodegradable polymer packaging). I was briefed on their work on vision systems and automation. Products included road safety systems used in NSW, a load-haul-dump navigation system using relative control (a successful competitor against the SLAM approach, preciously described, of the Center for Field Robotics at U Sydney), and a baggage handling security system in Sydney Airport. Their forte in this general area is real time video DSP and analysis, and they have developed their own programmable processors. I was also briefed on their work in joining technologies, in which they have submitted several preproposals. The ones I found most interesting were for development of design guidelines for keyhole gas tungsten arc welding of high performance alloys, and processes for the production of gears without machining, using precisely controlled local superplasticity. I then toured their facilities and saw several of their other capabilities including nanopowders (they have developed a technique that is competitive with the one reported earlier from UWA), x-ray ultramicroscopy, fuel cells and ceramic membrane oxygen separation (Rich Carlin's team is familiar with this work), and light alloy development.

CSIRO Molecular Science conducts research in specialty chemicals and environmental technologies, protein and pharmaceutical sciences, applied chemistry and polymer science, biotherapeutics and drug delivery technologies, chemical processing, and biomaterial surfaces, cell signaling and interactions. They have over 300 staff with labs here in Melbourne and in Sydney. With DuPont Australia, they have formed a joint venture company, Dunlena, to develop, manufacture and market bioactive compounds for agriculture (both in-house, and via collaboration with outside researchers who have synthetic compounds with potential biological activity). Dr Heather St John and colleagues gave me a tour of their facilities, focusing on composites research and life cycle testing, and polymer surface films to prevent biofouling. One very interesting procedure that they have been working on for several years is Quick-Step, for rapidly curing composites without the use of an autoclave; it works by very rapidly heating a liquid between heavy membranes. The Quick-Step process apparently produces results that are comparable in all ways to standard layup and curing, but in minutes instead of hours. I later discussed this process with Ian Mair of the CRC for Advanced Composite Structures, who noted that CSIRO has been working with it for several years, and while it should be effective for some applications, it has to date been used for only small items (less that 1x1m), and may not be appropriate when close tolerances are required.

As an interesting contrast in approaches, and a good example of CSIRO competitiveness and interaction with industry, the Manufacturing S&T Division proudly displays their optical security technology, used to defeat counterfeiting in paper money and American Express

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[146] Business enterprises 46%; State Gov't Agencies 11%; Higher Education 25%; Other Federal Gov't Agencies 6%; other 2%

[147] Agrbusiness accounts for 34% of CSIRO's work; Environment 18%, Minerals and energy 18%, ICT & Services 11%, Chemical and Drugs 8%, engineered manufactures 7%, and radio astronomy and measurement standards 4%

Traveler's checks. Its next door neighbor the Molecular Science Division, on the other hand, working with Note Printing Australia (a subsidiary of the Reserve Bank of Australia), developed the polymer banknote that has completely replaced paper money in Australia.

Aerosonde™'s product is a small (~3M wingspan, 15Kg weight, 5Kg payload), GPS-navigated AAV (Global Robotic Aircraft Observation System) designed to cruise at relatively slow speeds (80-150 kph) at altitudes up to 7km for up to 30 hours. It was originally developed by the company's president Greg Holland, formerly of BOM, for meteorological sampling. Over the last 8 or so years, he and his small company have progressively improved its capabilities (with some support from ONR, for a trans-oceanic flight), and it is now widely used for scientific experimentation around the world, including considerable Arctic research for NSF and other US sponsors. On the day of my visit, the company (20% owned by Saab Aerospace) had gone public on the stock exchange and was doing well, and Greg and his team were preparing to stand up their new 'global command center' to control experimental flights about to be launched from Korea. Up till now they have flown their operations from deployed teams, but satellite comms now enable them to relieve the field groups of their flight management responsibilities.

In addition to its contract research and sales, the company already has several aircraft deployed in standby condition for Australia, and their new remote control procedure will significantly increase their responsiveness for the sort of ISR operations that are becoming of greater interest to both their and our Defence organizations, as well as to BOM etc for extreme weather events. Although there are much 'fancier' (and more expensive) autonomous platforms under development, Aerosonde™ has a proven track record in extremely demanding environments, is low cost (the platform is essentially throw-away when tactically necessary), and can provide continuous coverage with a small field team for launch and recovery and a limited number of aircraft. The aircraft is easy to launch (from car, ship, or catapult -- basically anything, anywhere, that can get it up to 80 kph flight speed), and robust. From a business perspective, Greg noted that it will probably be several years before they turn a profit, simply because they have such an accumulated reserve of R&D credits from their first years of operation. I was impressed with the simplicity yet effectiveness of their operations and facilities, and commend them as excellent example of what an Australian technology-based SME can accomplish if the leadership is innovative and dedicated. There are many uses to which our Navy could put this system, while continuing its own developments.

BMRC: The Bureau of Meteorology Research Center is internationally renowned for its work in ocean, atmospheric, and climate modeling, and numerical weather prediction (NWP). ONR and NRL (Monterey) have a long history of collaboration with BMRC[148], in particular in tropical cyclones and data assimilation; so, as with CSIRO and DTSO, I need not belabor the details. BMRC is collocated with the BOM's headquarters and major NWP facilities in central Melbourne. They share access to the NEC SX5 supercomputer (routinely upgraded - next in about 2 years), and this closeness -- as between NRL and FNMOC in Monterey -- enhances their value to the principal user (weather forecasting) community; they are an excellent model for 'tech transfer' from research to operations. In contrast to the US, where NOAA provides forecasts and warnings (and climate, etc, services) for CONUS and Navy has responsibility for the rest of the globe and in particular for DOD, BOM/BMRC serve both military and civilian needs. In addition to their national responsibilities, BMRC scientists play a major role in international atmospheric,

[148] We have had many personnel exchanges, and routinely support their research at the US $250-500K/year level. Their expertise in Southern Hemisphere characteristics and processes nicely complements Navy's own skills. Our relationship with BMRC is exemplary of the type of cooperation we wish to further inspire, where groups with comparable expertise and a similar approach to S&T and modeling can enhance each others' efforts because of similar interests in differing environments.

oceanic, and climate prediction programs, largely because of their recognized world class expertise. This is one area where Australia is without doubt performing at the peak of the international level; and, their skills are of great importance to DOD, to the degree that we will be operating in tropical, West Pacific, Southern, or Indian Ocean areas.

BMRC has about 85 staff, making it one of the largest organizations of its kind in the world. Its reporting chain is through BOM to Department of the Environment. While it is supported principally by federal funds, it also receives significant contract support both from other Departments, and from the international community (including in the US, NASA and DOE as well as ONR). It works very closely with CSIRO, in particular with the Marine Division in Hobart (for ocean modeling), and the Atmospheric Research Division in Melbourne (for atmospheric chemistry and air quality). Over the last few years, the BOM's principal effort has been to develop the "Australian Integrated Forecasting System"; having completed that, the current focus is on nowcasting, and the "Forecast Streamlining and Enhancement Program".

In addition to Management, BMRC has sections for Model Development, Data Assimilation, Model Evaluation, Weather Forecasting, Climate Forecasting, and Ocean and Marine Forecasting. I met with the Director Mike Manton, with his immediate supervisors to discuss Defence interests and collaboration, with Neville Smith who heads the Ocean division and is the international leader of the GODAE program; and was briefed by staff on their work in tropical cyclones, nowcasting, and data assimilation. Recent results in advancing the theory of tropical cyclone boundary layer winds were particularly impressive; the theory has been published, but I also saw new comparisons with data from several storms that shown extremely close agreement. This work is of major importance for storm track and intensity prediction, one of our highest METOC priorities.

It is worth nothing that what makes BMRC's work of particular value to the US Navy is the similarity of our approaches for data management and numerical weather prediction. We both use nested models, and both have adopted the observation-space approach to assimilation. BMRC's operationally oriented research is thus actually more compatible with ours than is NOAA's. Further, their weather and climate data collection systems, their XBT program, and their major Darwin Climate Modeling Research Station, provide invaluable data.

Monash University: Monash and the University of Melbourne are Victoria's two members of the "Group of Eight": the best of the 37 Australian Universities in research, those that win the vast majority of competitive funding grants. The Deputy Vice Chancellor and VP Prof Peter Darvall noted that, as Melbourne's second University, Monash developed a high percentage of foreign students -- 7K out of a total of 40K (~5K graduate) -- and is now heavily dependent upon international student fee income; they have campuses in Malaysia, South Africa, the UK, and Italy. Monash has a very broad program (most everything but dentistry and agriculture), and is particularly strong in engineering and science, medicine, and pharmacy. The adjacent CSIRO Divisions (on land taken from the University) provide added strength in chemistry and materials. Their 'jewels in the crown' however are the Institute of Reproduction and Development (they have several 'legally legitimate' lines of stem cells, derived from discarded embryos in Singapore), and the Accident Research Center (a University Center that is totally supported by soft money), which has dramatically lowered the road trauma rate in Victoria. Prof Darvall stated that Monash did very poorly on the recent ARC round; he had complained to Vicki Sara about the imbalance of referees from the various states (too many from NSW), but more seriously was about to launch a detailed investigation into the reason for their poor performance.

We spent some time discussing IPR. Monash owns all the IPR from its staff (students however have IPR rights in work from their research), but shares revenue 1/3 each with the University, Department and inventor. He contended that Monash had never had an instance where the University let IP escape to the benefit of others; on the other hand, neither have they

(or any other university) made significant profits. IPR is however very valuable for building collaborations and partnerships; he contrasted their policy with that of Melbourne University, which vests all rights in its staff, and therefore has no way to bring IP to the table as part of a joint or commercial venture with the State, Federal Government, industry, or other potential partners. Following lunch and considerable discussion about biomedical research, I met with separately with Prof Rhys Jones of Engineering, and David Karoly of Math (and Atmospheric Sciences).

The Mechanical Engineering Department has about 25 academics, 700 undergraduates, and 80+ graduate students, and the highest student entry scores in the country. Prof Jones' group has 5 academics, 2 instructors, 4 postdocs, and about 15+ PhD students. It also manages the BHP Institute of Railway Technology, a ~$2.5M operation that conducts R&D for "the heavy haul operations of BHP Iron Orem, and rail and steel sleeper development programs for BHP steel, as well as contract R&D activities for Australian and international railway operators, railway contractors, and manufacturers and suppliers of railway equipment and consumables" (brochure). Prof Jones stated that they work for Honk Kong, Singapore and Malaysia, and that they do an additional ~$2M of maintenance research. We toured their facilities which included a large subsonic wind tunnel (used by yacht racers and automobile companies, and for city models to look at flow around new buildings, bridges, etc; this facility is commercially operated by a company established for the purpose), a new $3.5M Cray supercomputer that had just been competitively won by ME and EE, laser holography and structural test labs, robotic fiber layup equipment, and a new impact-under-load test facility based on a Wright Labs design, with which they will do research on damage to composite materials for the USAF. Following Dr Majumdar's recent visit, Prof Jones had sent him a preproposal for studies of coating degradation during operations, using coated fiber optics.

Prof Karoly (who was a lead author in the Detection and Attribution section of the recent IPCC Climate Change assessment) heads the School of Mathematical sciences, and is the leader of the recently established undergraduate program in atmospheric sciences (they also have about 25 graduate students). At the time of the Dawkins reforms, when Monash amalgamated with several other campuses, there were about 65 faculty in the various math groups; now there are 22. He believes however that the bottom has been passed, and morale is improving; they are advertising for 4 positions in Math, and the government perception about the value of S&T is turning around, albeit much of the increase is in targeted programs (e.g., almost all of the first year increase for ARC went into the new Federation fellowships). One remaining difficulty is that under the formula for university funding, lab sciences like physics get twice the credit of subjects like math. He recently argued successfully for the treatment of atmospheric sciences as a lab subject.

In general, ocean and atmospheric sciences are scattered throughout small groups or individuals in the various Universities. For a while Dr Karoly headed a CRC for Southern Hemisphere Meteorology, but it failed to get its second round largely because there weren't enough important research areas outside the core work of CSIRO and BMRC (who saw it in a way as competition) to justify it. However Monash has a very close relationship with BMRC (Prof Karoly's chair is supported 50-50 by BOM and the University), and his School together with Geography and Environmental Science still operate the Monash Center for Dynamic Meteorology and Oceanography.

RMIT and CRC-ACS: The Royal Melbourne Institute of Technology, founded in 1887, is one of Australia's largest and most diverse Universities, with close to 50K students and courses that run from technical certificates (TAFE) through PhDs. It has six campuses in the Melbourne areas, plus several overseas, including one of the Faculty of Engineering in Vietnam. The Engineering faculty has some 9K students (about half TAFE, half higher education; and half full, half part time), 520 staff, and 10 Departments at four sites. Its 5-year, double degree (e.g.,

aerospace engineering and business) programs are particularly popular, and attract the top students. The Aerospace Engineering Department has about 25 academics and 20 additional staff, with 500 undergraduates and about 100 postgraduates (50/50 MS and PhD). It has a very broad set of activities, including TAFE and higher education, R&D and consultancy, flight training, and advanced training in aviation science and management, delivered in both Taiwan and mainland China. In 1991, together with the Math Department, it established the Sir Lawrence Wackett Centre for Aerospace Design Technology, which has "responsibility for research, consultancy and continuing education programs in aerospace, aviation, and related disciplines". It is a DSTO Centre of Excellence in Aerodynamic Loading, and one of the major participants in the CRC for Advanced Composite Systems. In addition to its continuing education and training programs (its customers include RAF, RNZAF, and the Singapore AF), and participation in postgraduate research, it conducts aircraft design and analysis, systems engineering, static and dynamic testing, and some flight certification.

CRC-ACS was established in 1991, as one of the first-round CRC's. Its partners include Boeing/Hawker de Haviland, DSTO/AMRL, GM/Holden, RMIT, Monash, UNSW, U Sydney, U Newcastle, and some smaller companies. It has a wide range of R&D and analysis equipment at its various partners facilities. It has been very productive, and since Boeing is in the process of expanding its composites production capabilities in Australia (and going from tier 2 to tier 1), it is likely to fare well in its bid for a third round next year[149]. Further, CRC-ACS's headquarters are in DSTO's facilities at Fisherman's bend, so it has a very close relationship with the Defence forces. Its programs cover materials science, improved manufacturing, structural performance, operations, and education; in the course of its research it conducts tech demos. It is already conducting some research for ONR, and the CEO Ian Mair recently visited Steve Linder of ONR 36 and the South Carolina Research Activity, with which it shares many interests; so we are very familiar with its capabilities. I would suggest that this CRC may well be an appropriate one for ONR to consider joining as a partner (full or associate), particularly if Dr Majumdar is stationed in Melbourne, where he could very closely follow its work.

C. Tasmania Observations

Tasmania is the smallest and least wealthy of the Australian States, but nonetheless contains a number of institutions of significant S&T interest, principally in marine sciences. CSIRO Marine Research (CMR) in Hobart has an excellent international reputation in oceanography and fisheries research, and the Antarctic CRC has done some first class research on the Southern Ocean. The Australian Maritime College in the north has excellent facilities for hydrodynamic studies, and already works closely with DSTO; their recent $4.5M Major National Research Facility award will further improve their capabilities. Even TIAR, the state/university agricultural research group, has activity of interest, since one of the products it is studying has significant potential as an antifoulant.

One very valuable characteristic of Tasmanian institutions is their willingness to collaborate. With a small population and little financial support from the State, their natural inclination is to cooperate with other organizations throughout the Federation, and of course some Tasmania-based federal organizations such as CMR and the Antarctic Division have broad national responsibilities. Surprisingly for a marine oriented country, one very significant deficiency is lack of a world class research ship. CSIRO is planning to sell the national research vessel, the *R/V Franklin*, to get the funds to upgrade and convert its fisheries research ship, *R/V Southern*

[149] This year's DISR budget for CRCs was $145M; next year, it will be $193M, then $243M, indicating the government's positive view of the program's success.

Surveyor; and even then, they will only be able to operate it (for the nation) 180 days per year. Even their Antarctic resupply vessels are chartered. Given the size and economic as well as strategic importance of their ocean area (their EEZ is about 2.5x the size of the continent, and marine resources provide A$42B/year [$22B tourism, $9B oil & gas], about 5% of GDP), this is in my opinion a major problem. Another problem is the fact that responsibility for marine affairs is very widespread, and interagency dialog is not strong[150]

Finally, although Tasmania likes to think of itself as quite isolated (and from the standpoint of natural beauty this is a great advantage), it is really quite close to Melbourne, and the overnight ferry (for someone used to traveling in Scandinavia) is extremely convenient. Given DSTO's interest in increasing its submarine-related research -- looking beyond the Collins Class -- and the quality of the research facilities at AMC, the simplicity of the commute will become more important. It is also worth noting that Dr Majumdar is well acquainted with the AMC facilities and staff, and highly respected by them, which should further increase his value to both Australia and the US should we be able to post him to Melbourne.

D. Tasmania Visits

CMR: CSIRO Marine Research is located in very nice 1980's facilities at the end of Battery Point in Hobart. Its Director, Dr Nan Bray, is an MIT/WHOI graduate in Physical Oceanography, who conducted her research at Scripps Institution of Oceanography until she came to Hobart on a sabbatical in 1995, then was selected as the Director of CMR when CSIRO combined the two previous labs at the site -- fisheries and oceanography -- to form a single marine research organization. CMR has 350 staff of whom 65 are research scientists, and its revenues are about $35M/year, of which 35% is external[151]; Dr Bray noted that given how overhead is managed, this means that individual PI's have to raise about half of their revenue, which nearly totally leverages their core funding since outside sponsors are generally unwilling to fund over half the cost of a project. This leaves them little opportunity to pursue new research directions or develop new capabilities, particularly since there is no organization to which their scientists can propose merit-based science; they are 'reduced to doing deals'.

CMR's overall mission is to provide a scientific basis for the ecologically sustainable development of Australian marine resources, and assess the ocean's role in climate variability and impact on terrestrial resource productivity. Dr Bray noted that Australia is rich in policy, albeit light on resourcing; their overall priorities come from the Australian Oceans Policy, but the only part of that very broad policy that was funded is the development of Regional Marine Plans ($50M over 3 years); the associated Marine S&T Plan was not funded at all. The Oceans Policy is overseen by the National Oceans Office, also in Hobart; they are starting development of the regional plans with the SE. One contentious (albeit scientifically proper) aspect of these plans is that they are based on natural ecosystems, which do not align with State boundaries. As a result the States (which have responsibility out to at least 3nm) haven't bought into the process, so the plans are focusing on the resources on the shelf and slope. Another major policy which influences their efforts is the Environmental Protection and Biodiversity Conservation Act.

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[150] The states have responsibility for coastal waters, and often do not see eye to eye with the feds. At the Commonwealth level, there is an organization known as HOMA -- Heads of Marine Agencies -- but it is basically a forum for exchange of ideas, and has no authority or resources. The one issue it has done well with, apparently, is data management, although the role of AODC is problematic.

[151] The largest sponsor is the Fisheries R&D Corporation, a voluntary association of fishermen whose contributions are matched 3:1 by the commonwealth. Other sponsors include the States, who also weigh in heavily on what CMR's priorities overall should be, other federal departments, and SME's, which Nan referred to as the 'clients from hell', since they are so reluctant to pay for R&D support.

CMR's resources and staff are broken down into 5 research, and two support programs: Multi-Use Management of the EEZ (basically, the science behind risk assessment for management of resources for ecologically sustainable development; this work is performed in close cooperation with the National Oceans Office); Tropical and Pelagic Ecosystems (in partiucular the impact of fisheries on ecosystems); AIMS in Townsville -- a Federal organization but essentially 'captured' by Queensland -- does much of this for the Reef area, and CMR is a 'research provider' to them); Ocean and Climate; Coastal Waters; and Aquaculture and Biotechnology; plus Marine Technology and Information (integrated responsibility for ships, library, electronics, etc…Nan says this is working well), and Resources. We spent some time discussing their work with Defence. They actually have little interaction with DSTO (which used to be part of CSIRO but was separated for security reasons), but have had a long history of collaboration (though little funding) with RAN. One example was the TOGA-XBT network which they managed from 1983-97, and has now become a part of BOM's operational network. CMR recently supported 10 ARGO floats (via a Chief Executive block grant), and experience from the floats' performance led to modifications to enable them to operate properly in warm shallow water. A major project now in the works (on the Defence Minister's desk for final approval - albeit it will have now to wait till after the election) is an Ocean Analysis and Modeling System, supported over two years at the level of $6/3/6M by RAN, CMR and BOM. This will produce a set of nested, coupled ocean-atmosphere models with data assimilation, that should vastly improve their forecasts and operational (e.g. acoustic propagation) predictions. This work should be of significant interest to ONR, and I suggested that they should interact with Terry Paluszkiewicz of ONR 32, to develop collaborations in ocean modeling that can complement those between BMRC and NRL Monterey.

Antarctic CRC: This was one of the first 'Public Good' CRCs (1991), and its partners include the Australian Antarctic Division, BOM, CMR, AGSO, and the University of Tasmania, where it is headquartered. Its principal focus has been the role of Antarctica and the Southern Ocean in global climate change, and it has made many scientific contributions, including finding a new source of Antarctic Bottom water formation off the Mertz Glacier, and determining that Antarctic Intermediate water has freshened considerably over the last 25 years, implying about a 20% increase in rainfall. This influences the CRC's prediction that the Antarctic ice sheet will continue to grow for the next hundred years or so, as the impact of increased precipitation will be larger than that of warming. The CRC has also done considerable biogeochemical assessment and modeling, as well as studies in paleoclimatology, ice sheet dynamics, microbial diversity, and Antarctic law and policy. It has over 60 staff, and 50 postgraduate researchers. In spite of its acknowledged scientific excellence its future is problematic as it tries for its third round next year. It is therefore in the process of defining new research programs, and looking both for international partners and commercial support (via a consulting company) to meet the new program guidelines.

AAD: The Australian Antarctic Division, an agency of Environment Australia, "manages Australian government activity in Antarctica, provides transport and logistic support, maintains the four permanent Australian research stations[152], and conducts and manages scientific research programs both on the land and in the Southern Ocean" (brochure). It has some 280 staff at the headquarters in Kingston (16 m south of Hobart) , and another 80+ on station at the moment. The annual budget of about A$104M covers overhead, staff, and logistic costs, and the science program which has both intramural and competitive grant components. The science program has

[152] Three on the continent: Mawson, Davis (which is overcrowded this summer) and Casey, and one on Macquarie Island, which is part of the State of Tasmania. AAD is also responsible for Heard and McDonald Islands, an "external territory of Australia".

10 strategic objectives, each with a lead agency (AAD unless otherwise specified): Antarctic marine living resources, atmospheric sciences (BOM), biology, geosciences (AGSO), glaciology, human impacts, oceanography (CMR), human biology and medicine[153], cosmic ray physics, and astronomy.

They currently resupply by ship (the Australian built *Aurora Australis*, operated under charter to AAD by P&O Polar Australia, and on occasion the Norwegian *MV Polar Bird*), which is both costly and so time consuming that many senior scientists simply send their students. They are seriously evaluating the possibility of shifting to air support, which will save money, improve access and flexibility, and significantly change the demands for ship time and operations[154]. Another significant issue is the possibility of submitting their data for an extended continental shelf under UNCLOS. Australia has a 42% slice of the continent, the result of a transfer of part of UK's claim in 1936, before there was an Antarctic treaty. Australia contends that its territorial rights are not diminished by the treaty, and that as a consequence they have inherent rights to an EEZ and an ECS (i.e., the ECS is not a 'new claim' as prohibited by Article 4). They have collected most of the required data, but whether or not they will submit it for a claim (which they must do by 2004) is a decision that will have to be made by the government at the time.

University of Tasmania and Tasmanian Institute of Agricultural Research: I had asked to see Prof Bob Menary largely because of his position in the Australian Academy of Technological Sciences and Engineering (which is sponsoring a National Symposium on "Looking South - Managing Technology, Opportunities and the Global Environment" this November; I referred him to ONRIFO Tokyo Office for possible CSP sponsorship), but we had a wide ranging and fascinating conversation that included his own research on essential oils. UT has about 8K students, 20% non-local; most of the students are at the main campus in Hobart, but it also has facilities in Launceston (collocated with Australian Maritime College) and Burnie. The Agricultural School, which together with the Department of Primary Industries, Water and Environment operates TIAR, has about 150 undergraduates and 80 graduate students. The University also hosts the Temperate Hardwood Forest and Marine Conservation and Aquaculture Centres, in addition to the Antarctic CRC.

I had driven south to Hobart along the west coast, and so didn't appreciate the importance of agriculture to Tasmania until I drove back north through the midlands. In addition to sheep (wool is the #1 product), Tasmania has significant beef cattle and dairy industries (and excellent cheese); but also many 'specialty' products, including deer, quail, emus, salmon, oysters, fruits, hops (pesticide free; this industry has been bought out by the US and Germany), and opium poppies for morphine and codeine (15K hectares). Also vegetable processing; Tasmania has the world's highest productivity of peas. Soils and temperatures are similar to those south of Portland, and the clear skies, rain at the right time and acid soils produce superb Riesling, Chardonnay, and Pinot Noir, which are beginning to take their proper place in the world market (even a mainland Chinese firm recently planted 200 acres). Further, because of the quality of the environment and ecology, Tasmania is a superb locale for development of volatiles, and thus essential oils for flavors and fragrances. As an example, Tasmania has 2/3 of the global production of natural pyrethrum for insecticide. Prof Menary spoke of two species in particular. The first is Tasmania lanceolata (Tasmanian Pepper) which is already used in many products in Japan, but needs minor additional testing for FDA approval as a foodstuff in the US. Of possible interest to ONR, it contains polygodial, an aromatic with potent antimicrobial properties; he has

[153] This program is partially supported by NASA; the Australian stations' isolation is seen as a physiological and psychological analog to remote space travel. Also, NASDA just hired one of their senior medical scientists.

[154] E.g., if they can do most of the logistics by air, they will be able to afford to operate the ship as a mobile research platform off the coast for the full summer season.

just received an ARC grant to examine its capabilities to prevent fouling when synergists are added; he will send a summary of this work. The second is Boronia megastigmata, which in very small quantities dramatically enhances flavors of citrus products, fast foods, etc. Its flavor enhancing properties could be very useful in processed foods such as MREs.

AMC: The Australian Maritime College has a total of about 2500 students, including vocational (qualifications & upgrades for mariners and fisheries workers) and higher education. It offers two degree programs, engineering (naval architecture, maritime engineering, offshore structures, ocean engineering and hydrodynamics, etc) at the Newnham (Launceston) campus, and applied science (including an MBA program) in fisheries and marine resource management at Beauty Point, about 50 km north along the Tamar River valley. It also has about 10 PhD students. To purvey its capabilities commercially, AMC has a wholly owned subsidiary, AMC Search Ltd, which had a 2000 gross revenue of ~$5M. This company provides maritime training to Kuwait and Malaysia, does considerable port and harbor development work using its navigation simulator and associated computer graphics capabilities, conducts maritime operations training, and does some work for the Australian Defence Forces, including training the PB crews for their patrol and customs duties. Until 2000, AMC also hosted and was the principal partner in the Australian Maritime Engineering CRC (which failed to get a second round of funding and is now closed)).

I toured AMC's impressive array of facilities, which will be very useful for collaborative S&T. These include a cavitation tunnel (.6x.6x2.6M test section, 12m/sec max velocity, 10-400kPa pressure) for propeller and water jet development and evaluation; a model test basin (12x35x1m with multielement wavemaker) for experiments on maritime operations in shallow water; a towing tank (60x3.5x1.5m, carriage speed to 4 m/sec, with wave generator); a flume tank (at Beauty Point) for testing nets and underwater vehicles; and a marine simulation center (ship handling, ship operations, and engine room simulators) with models of many Australian, NZ, and SE Asian ports and harbors, and the ability to develop and test new harbor designs. AMC recently received a $4.5M Federal Major National Research Facility Grant that will expand these facilities (e.g., increased capabilities of the cavitation tunnel, add 40M to the towing tank) and let them hire an additional 5 researchers. They also have a range of ships and boats, including the Bluefin, which I visited; she can carry up to 20 students/researchers and is well fitted for a wide range of sampling and fisheries training and research.

E. Adelaide Observations

Adelaide is a very livable town. What it lacks in overt dynamism -- compared say to Melbourne and Sydney -- it makes up for in convenience and, from the standpoint of S&T, good collaboration among the Universities, a heavy Defence development presence with DSTO and ASC, and a well-connected, ambitious local intelligentsia that refuses to be left behind. I had been told that South Australia was pastoral, dry, and sleepy. The first two may be on the mark, and the state may have made some significant mistakes in the past (e.g., the collapse of the state bank a number of years ago, and the Multifunctionpolis [MFP] that came to naught) -- but my sense is that they are now getting some very astute guidance on how to invest for the future (at least with respect to technology), and if the government is smart enough to listen then they should at least be competitive in the Defence and electronics sectors, if not quite up to investing head to head against Queensland and Victoria in the quest for ICT and BT dominance in the country.

South Australia is relatively small and agricultural, and lacks the financial resources of some of the other states. However is does have significant strengths, many of particular interest for ONR. Among South Australia's resources in and around Adelaide are three excellent Universities -- the young and growing University of South Australia which focuses heavily on industry, Flinders

University with strengths in humanities and medicine, and Adelaide University (which I visited, see section F), one of the nation's premier research universities, with a particularly strong reputation (one of the top three in the world) in agricultural biotechnology, and a leadership role in BT commercialization. DSTO's electronics and IT segments are a strong attractant to industry, and helped attract BaE Systems to name Adelaide as its Australian headquarters. SAAB and Tenix also have local facilities, as do Motorola (see Report 8) and EDS. The Australian Submarine Corporation is near Adelaide, and its future, albeit still somewhat problematic, is the centerpiece of the shipbuilding component of the country's defence industry strategy; it is highly likely that in spite of Western Australia's efforts to attract marine work west, ASC will remain where it is. And there are several thriving industrial parks which have university or defence backing to help encourage SMEs and spinoffs.

Thus although the SA government has been less than visionary with regard to S&T for the past 5-10 years, it has a good base for expansion; and, I was told, it is now starting to make some wise investments. As an example, as I understand it, SA has supported Chairs in IT&C at each of the Universities, and brought them together as an SA Consortium. The state will support a bid with the universities and industry for the new federal ICT Center of Excellence, and also has funded a major demonstrator project for wireless communications which will provide wide bandwidth connectivity for a large segment of central Adelaide, that includes parts of the AU and U SA campuses. They are also providing pre-seed funding (matching private capital 3:1) for very early stage commercial development, and the universities (at least AU) are linking up with investment advisors and funds managers to take advantage of the opportunity.

The attractants from ONR's perspective are similar to those for industry, and focus in particular on the defence sector. As in Melbourne, DSTO (see below) is without doubt the partner of immediate interest as our Navies' strategic relationships develop, but as DSTO starts to spend more in industry, and as the country as a whole gains S&T strength based on federal as well as state investments, the primes, SMEs, and universities in Adelaide will provide a rich resource of new ideas and technology.

F. Adelaide Visits

DSTO: DSTO has a large contingent of researchers in Salisbury, located next to the RAAF Edinburgh base, about 30 minutes drive north of city center. This site houses most of today's Electronics and Surveillance Research Lab (ESRL), plus the Weapons and Maritime Operations Divisions of AMRL. My principal host was Dr D. (Nanda) Nandagopal, Chief of AMRL's Maritime Ops (the largest Division, with 224 staff and a budget of $19M). Nanda reminded me that DSTO's funding is now tied to the Defense budget (2%), meaning that it increases from $249M this year to $270 next. DSTO is about to reorganize, going from two labs to three. The new Information Systems Lab (to be headed by Neil Bryans, current Chief of ESRL) will have four Divisions: C2, responding primarily to requirements from Joint Command; Defence Systems Analysis, responding to DepSecStrategy; ISR, to DepSecISR, and Information Networks. The Electronic Systems Lab (Director apparently not yet named) will have Maritime, Air, and Land Ops Divisions, each responding to requirements from the appropriate Service Chief; and Surveillance and C/M, and Weapon Systems Divisions. The Military Platforms Lab (to be headed by Roger Lough) will have Maritime and Air Platforms Divisions, and the Centre for CNB Defence.

Maritime Ops plans are based upon a combination of the Defence 2000 White Paper, Navy's "Plan Blue" which has a 30 year outlook and incorporates VADM Shackleton's vision of

"Transformation Through Experimentation", Navy's "Plan Green" (10 year outlook), and an annually updated Navy S&T Priorities document. Principal requirements drivers include speed and agility, targeting, and extended range, to address gaps in littoral warfare, defence against low RCS ASMs, amphibious warfare, and systems integration, taking into account the need to be a 'parent Navy' (operating systems that others don't have), and to continue to use increasingly aging platforms. We discussed a number of the White Paper initiatives; in addition to the submarine enhancements and next-generation planning, the RAN program most likely to soon lead to yet closer strategic and technological ties between Australia and the US, is the new Air Warfare Destroyer (AWD). I see this project as being of particular interest for Australian Defence Industry from the standpoint both of shipyard rationalization, and the need for a choice (some time away) between AEGIS and the excellent indigenous S-Band phased array radar technology being developed by CEA. Under Project 4000, Maritime Ops Division is studying options for this ship (VADM Shackleton has asked our CNO for our requirements; ONR may want to offer to work with AMRL on this project, and simultaneously study their unique capabilities).

Overall, the major maritime S&T issues DSTO is addressing are electric propulsion/AIP (next generation sub), CEC and Network Centric Warfare, Phased Array technology, fibre-optic thin line arrays (using Bragg gratings tuned to selected frequencies), system integration (C&C, hard/soft kill), human factors, UAV/USV/UUV technologies, smart logistics and TOC reduction, and strategic S&T engagement with US and UK labs. Maritime Operations Division initiatives to address some of these include:

- the establishment of Centres of Excellence with industry and universities (e.g., the Combat Systems Research Centre (CSRC)), to prototype new concepts and algorithms[155]. In addition to CSRC they have COEs for ops research, network centric, and mine warfare, and will soon be setting one up for sonar;
- the Undersea Battle Lab and Virtual Ship, based on an HLA Run Time Infrastructure (I saw a demonstration of 8 federates interacting), with which they intend to participate in FBE Juliette next year (they also would very much like to partner in the US-UK VON program; I commend this idea to IFO and see no reason they shouldn't be a very important player in this S&T initiative);
- a proposal to be appointed Technical Direction Authority for the new Submarine Combat System (there has been no such thing before in Australian acquisition programs); and
- a focus on network enabled warfare.

I visited several Maritime Ops labs, and was briefed on torpedoes and torpedo defence, their work on fibre optic sonar arrays (impressive, and apparently at least as far along as our own at NRL. If this works, it will make a major difference in the fundamental nature of undersea sensing and multi-platform operations), the Battle Lab, and Virtual Ship. They are working closely with NUWC and NWDC to interface their virtual platforms and systems with ours, including as noted above, participation in FBEs.

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[155]While discussing some of the requirements for combat systems, such as data fusion, track management, and situation estimation, it occurred to me that the techniques developed for data assimilation and prediction in numerical weather forecasting may have significant applicability to maritime 'battle space awareness'. The basic problems are somewhat similar -- estimating changes in a 3D+T 'picture' of an area of interest, based on a combination of background information and new data acquired asynchronously from a wide variety of networked sensors of many different types, all with their own uncertainties. While there are certainly differences -- chaotic as it may be weather does obey physics; but then again, parameterization of that physics is not completely unlike target motion models -- there may be merit in a workshop to investigate how the some of techniques being developed by places like NRL Monterey, BMRC, and NCAR could be applied to the network-centric 'common operating picture' problem. I commend this idea to the IFO, and have discussed it with Otto Kessler of DARPA.

While the ship and submarine work is very high class, the most impressive demonstration I saw was of new capabilities within the Communications Division of ESRL (Shapes Vector), which I will discuss with Paul Lowell and Tom Handle upon my return. I was also very taken with their approach to S&T for decision making, in the 'Future Operations Centre Analysis Lab' (FOCAL). Their construct, which appears to be based on sound fundamental principles regarding conceptualization of a 'common operating picture', attempts to develop superior situation awareness through the integration of psychology and technology. My favorable impression was reinforced a couple days later by briefings from the psychology faculty at Adelaide U. I believe their human-systems based approach would blend well with some of the advanced data management technology that Lee Hammarstrom demonstrated for me at NRL. If Yvonne Masakowski visits Australia, this is definitely one of the projects she should spend some time with.

I was also briefed on DSTO's work with the Enhanced Sea Sparrow Missile (ESSM) and NULKA. The latter, it is good to recall, was an Australian invention; they are examining a number of upgrades including a new BaE Systems MEMS IMU and other techniques to enhance slow speed performance. In EW, they have their own version of SEI whose results correlate well with those of the NRL system; and they are working on a new integrated ESM suite that employs additional parameters to improve operator confidence. I also found it interesting that they are looking at a quite wide range of uses for Aerosonde (see Report 8), both for ISR and for EW. Aerosonde is rather ideally sized for EW payloads, and its low cost, simplicity, communications capabilities, and exceptional endurance make it a very interesting platform for littoral surveillance, particularly when it can be launched from and recovered to land. ONR was one of the early supporters of this system, and should very seriously consider follow-on applications.

The Alice Springs segment of the OTH Jindalee Operational Radar Network has been in operation since 1992, and was remoted to Adelaide three years ago. Although schedule slips and cost increases continue with the other two segments (apparently there was just a new 6 month, $30M problem), RLM -- which took over the development of JORN from Telstra -- appears to be well on track to finally bringing the total system on line, and all indications are that it will be a very capable surveillance system, especially against air targets. The US is quite familiar with JORN so I need say no more, except to note that I encouraged DSTO to again contact BOM/BMRC regarding extraction of wind and sea state data; they stated that BOM was not interested in the data, albeit as noted in my earlier reports I had heard differently both in Perth and Melbourne.

My final brief of the day was from Dr Jackie Craig, who directed Australia's recent tests of Global Hawk for maritime surveillance; the joint USAF/DSTO report has been signed off by both Project Directors, and should soon be available. The major challenges in this experimental program were working with Northrup Grumman and Raytheon to develop new sensor modes for maritime surveillance, and procedures for detecting and classifying targets on the same pass, since GH has a 20 minute turning time during which its sensors are inoperable. They also needed to develop a completely new, Australian ground segment to manage this new mode of operation, including inventing a 'virtual go to' tasking procedure that turned out to work better than expected. While the aircraft performed well and they completed most of the planned flights, considerably more R&D will be needed to perfect the sensor modes and operational procedures for maritime surveillance. Apparently I was the first US Navy rep to be briefed by DSTO on their results, and I would strongly recommend that someone from ONR or NAVAIR who is more familiar than I with both the GH system and our Navy's needs and plans for littoral surveillance, spend some time with Dr Craig and her team to gain an appreciation for the technical and operational lessons learned. The tasks the Australians attempted to perform with GH are very similar to many of our own needs, and it would be very foolish not to take full advantage of their experience.

CSSIP: The CRC for Sensor Signal and Information Processing, established in 1999, is headquartered in the Signal Processing Research Institute building (albeit there is no Institute) co-owned by the University of Adelaide, University of South Australia, and Flinders University, located 20 min northeast of the city in a technology park that was initially intended to be Victoria's 'Multifunction-polis" (MFP, a failed venture to attract offshore funding). In addition to those three Universities, (which have a 14.6%, 5.5% and 10.9% share respectively in the CRC), CSSIP's core participants are the Universities of Melbourne (14.6%) and Queensland (13.3%?), DSTO (29.1%), and industry (Telstra 3.2%, COMPAQ 5.1%, CEA 2.7%, RLM 1%). Its funds average about $10M/year, of which some 80% is supplied in-kind, and it has 40+ staff (the key researchers are a half-dozen academics) and about 50 PhD students. The CEO, Prof Don Sinnott, until very recently was Chief of the Surveillance Systems Division at ESRL. Based on the interests and S&T capabilities of its partners, CSSIP has 5 research programs, plus an education and a commercialization program. Research programs are:
-Sensor signal processing (headed by Prof Doug Gray, the Deputy CEO), with projects in SAR and ISAR, GPS, signal classification (e.g., the CEA navigation-radar ship-classification system mentioned in Report 8), and data fusion; much of this work is for DSTO, and underpins several of the programs I saw during my visit there.
-Image Analysis (Prof Mike Brooks, U Adelaide), projects in cytometrics (detection of early changes in visual appearance of cell nuclei caused by pre-cancerous changes at a nearby lesion), digital mammography, robust vision, information extraction from high resolution radars (with RLM), and pattern recognition (use of Support Vector Machines in classification of SAR images).
-Mining Sensors (Prof Dennis Longstaff, U Queensland), ground penetrating radar, and slope stability assessment (a real problem in open pit mining, requiring very precise measurement of very small, slow movement of the pit face).
-Distributed Sensor and Information Systems (Prof Vikram Krishnamurty, U Melbourne), multi-sensor multi-target tracking and information fusion (with DSTO's Data Fusion Lab), distributed systems design and simulation (conservation of water in large irrigation networks), and analysis of the performance of active communication networks.
-Area Surveillance (Prof Yuri Abramovich, CSSIP), focused on OTH radars, both JORN and a HF surface wave system, tested under contract to Telstra.

Using its IP, CSSIP has developed two spinoff companies. GroundProbe, focused on mining applications, is going through its initial venture capital phase. Wedgetail TRDC, a 70/30 venture between CSSIP and U South Australia, will develop a Training R&D Center under funding from Northrup Grumman and Boeing as part of Australia's purchase of the Wedgetail AEW&C (Boeing 737 with NG Multi-role Electronically Scanned Array [MESA] radar).

While Prof Sinnott and I spent much of our meeting discussing CRCs, South Australia innovation strategy, and Defence S&T issues in general, I gained enough appreciation for the work of CSSIP that I can strongly recommend it as a candidate (along with the CRC-ACS in Melbourne - see report 9A) for ONR participation. In addition to its work directly for DSTO, it is an excellent point of integration for much of Australia's leading work in radar systems, and will very likely before long begin serious efforts in sonar. The leverage potential is very large, and the costs of a small share should be minimum.

Acacia Research Pty Ltd is a small HW/SW firm (~12 physicists, and Andrew Robb, a recently retired RAN submarine CO) that started about ten years ago building hardware to run algorithms for TENIX and other defense customers. Its resultant hardware expertise is in go-fast architectures, particularly for tracking algorithms and multisensor fusion. More recently, Director Ted Huber told me, they have started developing their own algorithms rather than simply building

what DSTO proposed. Their brochure notes that Acacia "operates in the broad area of C3; Surveillance and Combat System applications are the company's primary areas of interest. More specifically Acacia Research has had considerable exposure and developed considerable experience in submarine combat systems covering design of digital architectures, fault tolerant data bases, novel user interfaces, platform and sensor interfacing, multi-sensor data fusion (which was the main reason David Nicholls recommended them to me), detailed sensor and environment modeling. The main current project, which I saw in operation, is a Tactical Data Management System that features a multi-hypothesis tracker based on their multi-sensor data fusion module. The TDMS basically performs sensor data management, track management, TMA, and contact evaluation. RAN, which partially funded the development of this system through the previous Defence Industry Development Programme, has ordered three sets as part of the Collins Combat System Augmentation Programme; as I understand it, COMSUBPAC is also familiar with the system and is preparing to evaluate it at sea. It should also be adaptable to surface platforms. Ted Huber will be displaying this TDMS at UDT this year, and I would strongly recommend that any ONR or IFO visitors review its capabilities. Further, they have been in fairly close contact with, and believe they have complementary skills to, Anteon Corporation (POC David Lawrence, Senior Acoustic Analyst, 2341 Jefferson Davis Hwy, Arlington 22202; dlawrence@anteon.com, 301-227-5565) which should make it easy to follow up from ONR Hq. Basically, I found Acacia to be very similar in nature to many of the dynamic defense SME's I'm familiar with in the States; they're quite rare here by comparison, largely because the innovation environment stresses S&T in academia and government labs, and there is little in the way of RDT&E funding available for small business. This is an exploitation opportunity for us, I believe.

AU: Adelaide University (established 1874) is the smallest of the Group of Eight (the leading Australian Research Universities), with about 14K students (1500 international; 12% postgraduate), 1K faculty and an additional 1K staff. They did quite well in the latest ARC round, and typically are in the top two or three in the country on a per capita basis. Perhaps because they are relatively small yet very broad-spectrum, the barriers to interdisciplinary work at AU are low, and they are innovative in organizing for collaborative research and forming critical mass sized teams. As one example, they recently combined and collocated three previous Departments to form a very powerful Department of Molecular Biosciences that now has 250-300 research staff and over $14M/year in research funding, and has spun off three BT companies. This move enabled them to coordinate and consolidate their leading work, and share major research facilities, in genetics, biochemistry, microbiology, and immunology.

One of my hosts, Prof. Ian Young, is a coastal oceanographer with two current grants from ONR (PO: Linwood Vincent), thus very familiar with our programs, and outspokenly positive about ONR's management style. My other host, Prof Edwina Cornish, the Deputy Vice-Chancellor for Research, is unique among her peers from the other Universities that I have visited, in having come to the position from a small (biotech) business, rather than from the faculty. She noted that her selection caused quite a stir at the time, although I found her very impressive and effective, and from what I could tell everyone now seems very pleased with her performance. In addition to discussions with my hosts (their views on South Australia and national S&T strategies are reflected in the observations section, and in my to-be-prepared report on Australian innovation), my visit comprised a seminar featuring short presentations on research likely to be of interest to ONR by 10 members of the faculty (and a talk by me about ONR and the IFO), then a tour of the Thebarton campus, their 'Commerce and Research Precinct' (essentially a technology park) designed to promote the exploitation of University IP (they retain rights and share revenue 1/3 each with the Department and inventor, as does Monash), and couple their faculty with industry (AU also houses three national research centers, and participates in 15 CRCs -- with, I was told, somewhat problematic results). They also provided me with an inch-

thick booklet, developed specifically for my visit, describing a large number of research projects and the investigators' CVs. Overall, this was the most well organized and broad exposure to research that I have had at any university. They are clearly highly motivated toward collaboration and commercialization, as well as appreciative of ONR's interest (perhaps because of Prof Young's positive experience with us; irrespective, I am indeed grateful for the quality of their efforts).

The seminar presentations covered work in:

- Cognitive science and human factors (perception and decision-making, and human-systems interaction). much of which is coordinated with the DSTO FOCAL program (described briefly above); recent work focuses on quickness of thinking, involving the new concept of 'inspection time'. They also study prioritization, data visualization techniques, and pattern recognition in noisy backgrounds. If Yvonne Masakowski visits DSTO/FOCAL in Adelaide, she should also visit the AU Psychology Department (Prof John Taplin).
- The Department of Molecular Biosciences, mentioned above, conducts research in microbiology, immunology, human genetics, stem cell therapy, neurological development, and molecular biology/BT. It is acknowledged as world class, and benefits from a new purpose-build facility, as well as the University's teaching hospital (Dr Shaun McColl).
- Dr David Doolette of the Dept of Anesthesia and Intensive Care researches decompression sickness, and has accumulated an extensive source of data from aquaculture divers. His objective is to develop more physiologically based decompression procedures, and he conducts large animal (sheep) studies at the organ level. His worked seemed to me to be complementary to NMRL's.
- Prof Colin Hansen of the Dept of ME briefed their work on acoustics and vibration control. They are supported by AFOSR for research on aerodynamic noise control, and are developing a model that should let them reduce the number of control channels. Two aspects of their work that interested me were what they call 'virtual sensing', i.e. cancellation at a location remote from the sensor location, and the improvement they achieve by sensing energy density (pressure gradients) instead of just pressure.
- Dr David O'Carroll of the Physiology Department researches insect vision, and recently returned to Australia from UW Seattle. Much of his research uses single neuron recording from identified neurons to evaluate response to stimuli, and the subsequent development of biomimetic analog circuits. He is sponsored by AFOSR, directly and through an SBIR with Tanner Research Inc.
- The Special Research Center for Subatomic Structure of Matter (Prof Tony Thomas) is one of the world's three leading centers of nuclear theory. Its federal budget of ~$1M/year supports topical workshops and visits of leading subatomic physicists. They recently installed a 144 gflop Orion Supercomputer (and are moving toward a teraflop machine), which significantly increased their capacity for lattice simulations of quantum chromodynamics (QCD), one of their core research activities. They are also the lead site for the National Institute for Theoretical Physics, a networking center sponsored by ARC, and together with ANU have held some 50 workshops over the last six years; the intent is to stimulate all areas of physics throughout the country. In another initiative, with the Ionospheric Prediction Service of DISR, they participating in the World Institute for Space Environment Research; such initiatives, together with the strengths of DSTO, should help Adelaide develop into a leading center for space science in the Asia Pacific region. I suggest that Dr Baltuck follow up in detail.

I asked Prof Thomas about the status of physics in Australia, since I had heard such dismal reports elsewhere. He responded that over the last six years, physics faculties in the country have dropped from 360 to 240 staff. One problem they face is that much of their teaching is of a 'service' nature, i.e. basic physics for students in other faculties, so they don't get 'credit' in accordance with the counting system. When he returned to Australia in 1984, there

were 54 Physics PhDs at the 3 universities in Adelaide, including 22 at AU. Now there are 13 at AU, the University of South Australia has gotten rid of its Department, and what Flinders teaches would not be considered a physics degree elsewhere. He is not sanguine that the country yet understands the impact of losing its capabilities in such a basic enabling field. Nor am I.
- The National Key Centre for Research and Teaching in Social Applications of GIS (GISCA) was established in 1995, and is currently in its last year of federal funding. Its partners include AU, Flinders, USA, the Departments of Transportation and Environment, and the Australian Bureau of Statistics. The briefing presented several examples of their research in population dynamics, new technologies in spatial information, metropolitan and rural planning, health planning, and emergency management. One interesting product is ARIA, their Accessibility/Remoteness Indicator for Australia, that has had significant policy impact. Their Director, Prof Graeme Hugo, would be a good contact for any DESC or MEDEA interest in Australian GIS or GIS techniques.
- The Department of Physiology (Prof Caroline McMillan), ranks #1 or 2 among a strong field in Australia, and has major groups researching human movement (motor cortex control of finger movement using musicians as models, handedness, plasticity of the motor cortex after stroke, and exercise induced hypoxaemia in atheletes), cellular physiology and neurobiology (muscle function, myotonia, neurotrophic factors), and endocrinology, growth and development. In this latter area, the Research Centre for Early Development is looking at the perinatal origins of adult disease; the example presented showed how the incidence of cardiovascular disease is strongly correlated to birth weight related in turn to stress hormones during pregnancy.
- The Department of Physics and Mathematical Physics has research groups in Atmospheric physics, astrophysics, nuclear theory, mathematical physics, and optics and lasers. I was briefed by Prof Jesper Munch of the latter group, which is working on optical phase conjugation using stimulated Brillioun scattering, holographic correction of telescope aberrations, and a variety of lasers, including a competitor for the LIGO gravitational wave detection program.
- Associate Prof Chris Coleman of the EEE Dept, briefed on their work in antennas and propagation research. They have very close relationships with DSTO, as well as with many industries including Boeing and RLM. For the OTH systems, their research focuses on tools to understand the environment and the effects of scintillation, aimed at improved target positioning and coordinate registration in complex transmission paths. They are also conducting research on propagation inside vehicles and buildings, and the impact of lightning noise on HF communications.

The Thebarton Commerce and Research Precinct is a complex of old factory buildings about 4Km from the CBD, acquired by the University in very rundown condition (it has a fascinating history, including eucalyptus and manure processing) in 1990, and since run as a successful commercial enterprise, with the profits plowed back to pay for the upgrades of the infrastructure. It now has about 25K square meters of very nicely reconditioned building space, some 40 commercial tenants with about 450 people including 100+ postgraduate students, and room to incubate ~16 start-up companies a year. It also manages a couple of industry-linked education programs that places honors (4th year research) and graduate students with companies, to perform research that supports their academic programs; and has several other programs to encourage entrepreneurship by university or TAFE graduates, or AU staff and students. Two of the companies I visited there were FCT (Fuel and Combustion Technology Pty Ltd) that developed the torches for the Sydney Olympics (based on a simple but very clever vortex combustor), and ATRAD (Atmospheric Radar Systems Pty Ltd), that develops and sells MF and VHF radars for measurement of atmospheric phenomena. I was extremely impressed with the work of these SMEs, that both grew out of AU research. ATRAD, for example, is the logical commercial extension of the systems that Prof Robert Vincent first developed for his own

research, then provided when asked by colleagues. They now sell worldwide, and I was particularly impressed by the high power system they were assembling for China during my visit.

G. Comments and recommendations

I have already stated (Report 8) my primary recommendations regarding ONR's posture in Australia, namely that we should support and take advantage of the S&T Advisor at the US Embassy in Canberra for the sort of IFO functions we initially proposed for myself, and that we should station Dr Majumdar in Melbourne to work closely with RAN and DSTO on submarine related technology issues over the next couple years. It is expected that as the relationships between our two Navies and DODs evolves, our requirements will change (e.g., to address our joint interests in AAW and Australia's new air warfare DD, or in amphibious warfare based on US lease of Australian fast ferries, or in maritime littoral surveillance using a combination of HF radar like JORN, and AAVs such as Global Hawk and Aerosonde...there is indeed a wealth of opportunity for fruitful joint defence S&T); but Drs Baltuck and Majumdar will be in an excellent position to advise on such next steps after their close interaction with Australian defence labs, universities and industry over the next couple years. Enough for now to get started...and soon.

The major conclusion from this report, then, is that in addition to our connections to policy centers in, and outreach to academia from Canberra, Melbourne is indeed the correct location for a ship technology expert like Dr Majumdar to work from, albeit the other two locales covered in this report -- Tasmania and Adelaide -- also warrant close and continuous interaction. Tasmania is the national center of focus for marine S&T of interest to us, as well as the site of the country's major hydrodynamic research facilities. Adelaide boasts the electronics, ISR, ICT, and weapon systems center of DSTO expertise, to complement the HM&E work in Melbourne, as well as ASC. And, both are within easy commuting distance of Melbourne, and both -- but particularly Adelaide -- offer excellent opportunities for collaboration with industrial and university researchers.

The text contains a fairly large number of specific recommendations for IFO action. If I was to select just one for emphasis, it would be that human factors research associated with operations centers warrants a visit by Dr Masakowski (or her replacement) sometime within the next year or so. Both in the DSTO labs and in the universities, propelled by the interest in automation and combat systems, and more generally in ICT, Australian researchers have made significant advances in psychology and human development, and definition of architectural directions for decision making, that deserve our close scrutiny. I haven't yet tried to connect all the opportunities in this field into a coherent whole (and should wait till after Brisbane to try), but I do know that Australian research in physiology and psychology holds great promise.

Also at issue is the methodology for S&T collaboration. While our normal practice of sponsorship of individual researchers, alone or in collaboration with US or other international investigators as part of a Program Officer's coherent program, should of course continue, Australia's innovation system offers a unique opportunity for significant leverage through ONR participation in CRCs. I have noted two in particular in this report -- CRC-ACS and CSSIP -- that we should consider joining as core or associate participants, and am sure that there are more among the 63 or so across the country, that we would profit from. Further, as I suggested in Report 8, I am convinced that if our strategic relationship with Australia develops as anticipated, we will need new mechanisms overall for defence cooperation; again, this is something that will

have to be discussed with the many involved parties in DC. I can envision for example, joint development with Australian lead of components of low cost littoral surveillance systems; or first a workshop then possibly joint development of data assimilation techniques for battlespace awareness, based on our already mutually supportive work in weather forecasting; or joint development of their Ocean Analysis and Modeling System, which would prove of great value to our forces in their waters[156].

In summary, these three visits have simply reinforced the conclusions I reached during the first part of my Australian visit. There is much to be gained by both sides from significantly closer S&T cooperation, and we should proceed, with the support of the US country team, to establish the necessary mechanisms.

Itinerary

1 October, Monday: (Australian holiday): Arrive Melbourne ~1430, RON Novotel on Collins

2 October, Tuesday: DSTO (email = first.last@dsto.defence.gov.au) (phone +61 (0))

AM: AMRL, Fisherman's Bend; Overview, Director, Dr Bill Schofield (3 9626 7401); Air Operations Division, Director Mr. Colin Martin (7700); Briefs on JOANNE (Mather Mason, X7714); Helo-ship simulation (Robert Toffoletto, 7341); IFOSTP (Loris Molent, 7653); P-3C Fatigue Test (Philip Jackson, 7850), Active Vibration Control (Brian Rebbechi, 7592)

PM: AMRL, Marine Platforms Division, Maribrynong; Director Dr David Wylie (8200); Janis Cocking, John Ritter, David Saunders, Graham Johnston; Briefs on Sub Hydro (Brendon Anderson, 8620); UUV technology (Roger Neill, 8651), Propeller Analysis and Technologies (Len Davidson, 7290); Environmental Factors (John Lewis, 8418); Virtual Platform (Kevin Gaylor, 8577)

3 October, Wednesday: AM: CSIRO Manufacturing Science and Technology Division (email = first.last@cmst.csiro.au)

Chief, Dr Ian Sare (3 9545 2787); Deputy Chief Dr Allan Morton (2860); Briefs on Vision Systems and Automation (Grahame Smith), Joining and Thermal Processing (Laurie Jarvis (8 8303 9171); Tour of nanotechnology, materials modeling and polymer design and solid state ionics (Richard Hannink, 3 9545 2664; Dr S.P.S.Badwal, sukhvinder.badwal@cmst.csiro.au, 3 9545 2719)); microtechnology and x-ray ultramicroscopy, and light alloys (Allan Morton);

CSIRO Molecular Science Division, Dr Heather St John, Project Leader, Advanced Composites(heather.stjohn@milsci.csiro.au, 3 955 2446); Jonathan Hodgkin Sr Scientist (x 2446). Tour composites, polymer surface film labs

PM: aerosonde™, Greg Holland, President (gjhol@msn.com.au; 3 9544 0866)

4 October, Thursday: AM: Bureau of Meteorology Research Center, Director, Dr Michael Manton (m.manton@bom.gov.au; 3 9669 4444) & staff

PM: Monash University, Deputy Vice-Chancellor & VP (R&D) Peter LeP. Darvall (peter.darvall@adm.monash.edu.au; 3 9905 9300); Prof David Smythe, Biological Sciences; Prof. David Karoly, Head, School of Mathematical Sciences (david.karoly@sci.monash.edu.au; 3 9905 4416); Prof Rhys Jones, Dept of Mechanical Engineering (rhys.jones@eng.monash.edu.au; 3 9905 3809)

Dinner: Dr & Mrs David Wylie (MPD), Mrs & Mr. Janis Cocking (Submarines)

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[156]An interesting experiment would be to jointly fund, with DSTO, a BAA or RFP for a project of mutual interest, that was open to bid by both Australian and US SMEs and universities. My sense is that this would give us a good comparison of capabilities, identify leading players on both sides, and hopefully stimulate -- either immediately or through the development process -- some new international collaborations.

5 October, Friday: AM: CRC for Advanced Composite Structures, Ltd; CEO Robert Ian Mair (rimair@melbpc.org.au; 3 9646 8352); RMIT, Dept of Aerospace Engineering, Assoc Prof Adrian Mouritz (Adrian.mouritz@ems.rmit.edu.au; 3 9925 8069); Sir Lawrence Wackett Centre for Aerospace Engineering, Center Director RMIT Prof Murray Scott (m.scott@rmit.edu.au; 3 9925 8064)
PM: Report Preparation; Ferry to Tasmania

6 October, Saturday: Arrive Tasmania (Devonport) ~0830; transit toward Hobart via west; RON Cradle Mountain Lodge; Report preparation, night drive

7 October, Sunday: Arrive Hobart ~1500; Report Preparation. RON Lenna of Hobart

8 October, Monday: AM: CSIRO Marine Research, Chief, Dr Nan Bray (nancy.bray@hba.marine.csiro.au); 03 6232 5222); Program Leader, Oceans & Climate, Dr Gary Meyers, & Staff
PM: (1)Antarctic CRC, Director Prof Garth Paltridge (secretary@antcrc.utas.edu.au; 03 6226 7888); Dr Thomas Trull, Chem. Oc'r (tom.trull@utas.edu.au; 3 6226 2988); Dr Angus McEwan, Sr Sci Advisor, BOM
(2) Univ. Tasmania, Tasmanian Institute of Agricultural Research, Prof Bob Menary, (R.Menary@utas.edu.au; 3 6226 2723)

9 October, Tuesday: Australian Antarctic Division, Director Dr Tony Press (tony.press@aad.gov.au; 3 6232 3200); Asst Div Manager, ANARE Science Planning & Coord'n, Tony Molyneux (tony.molyneux@aad.gov.au; 3 6232 3396)r, Operations Kim Pitt (kim.pitt@aad.gov.au; 2 6232 3204)
Drive toward Launceston; RON Hudson Cottage, Ross

10 October, Wednesday: Launceston; RON Penny Royal Water Mill
Australian Maritime College, Launceston & Beauty Point; Dr Paul McShane, Director, Fisheries & Marine Environment (P.McShane@fme.amc.edu.au; 3 6335 4400); Paul Brandner, Manager, Tom Fink Cavitation Tunnel

11 October, Thursday: Report Preparation; Drive to Devonport; Ferry to Melbourne

12 October, Friday: Arrive Melbourne from Devonport, Tasmania ~0830; Transit to Adelaide; accident; RON Waterfront Motel, Apollo Bay, Victoria

13 October, Saturday: Transit to Adelaide @ Great Ocean Road; RON Anchorage Holiday Park & Motel, Port Fairy, Victoria

14 October, Sunday: Arrive Adelaide, South Australia ~1400; RON Stamford Plaza

15 October, Monday: DSTO; AMRL Maritime Operations Division, Chief, Dr D. Nandagopal; ESRL Information Technology Division, Dr Glen Smith (FOCAL: glen.smith2@dsto.defence.gov.au) and Dr Dale Lambert (dale.lambert@dsto.defence.gov.au; 8 8259 7175); Communications Division, Chief Dr Mark Anderson; Weapon Systems Division, Dr Mark Pszczel; Electronics Division, Chief
Dr Peter Gerhardy; Surveillance Systems Div., Chief Dr Bruce Ward, Dr Jackie Craig

16 October, Tuesday: AM: CRC for Sensor Signal and Information Processing, CEO Prof Don Sinnott (don.sinnott@cssip.edu.au; +61 8 8302 3477)
PM: Acacia Research Pty Ltd, Director Ted Huber (tedh@acres.com.au; 08 8345 1801); Engineering Development, Andrew Robb (andyr@acres.com.au)

17 October, Wednesday: AM: Adelaide University, Deputy Vice-Chancellor (Research) Prof Edwina Cornish; Pro Vice-Chancellor (International) Prof Ian Young; & staff
Lunch: Thebarton Commerce and Research Precinct, Director Industry Liaison Rex Hunter (rex.hunter@adelaide.edu.au; 08 8303 4468). ATRAD, CEO Robert Silva (rsilva@atrad.com.au; mobile +61 (0)438 805 253)
PM: Transit to Brisbane; RON Renmark Motor Hotel, Renmark SA

18 October, Thursday: Report Preparation; transit, RON Hamilton's Henry Parkes Motor Inn,

Parkes, NSW

19 October, Friday: Report Preparation; transit; Australian Radio Telescope; Dubbo Western Plains Zoo; Warrumbungle National Park; RON All Travellers Motor Inn, Coonabarabran, NSW

20 October, Saturday: Transit; Glen Innes; Bald Rock and Boonoo Boonoo National Parks; RON Settlers Motor Inn, Tenterfield, NSW

21 October, Sunday: Transit; Girraween & Main Range National Parks; Arrive Brisbane ~1300, RON Royal on the Park Brisbane; Goodwill Bridge opening, Gov't House, Botanic Gardens; report preparation

Report 10: 21-28 October, 2001: Australia Part 3: Queensland
A. Brisbane Observations
B. Brisbane Visits
C. Townsville Observations
D. Townsville Visits
E. Comments and Recommendations
Itinerary

A. Brisbane Observations

I visited only universities in Brisbane, so did not get as balanced a picture as in the other state capitals (I did however visit a second S&T Centre in the State, Townsville, so I got some appreciation for the divergence of views in Queensland). Queensland's motto is "The Smart State", and it is indeed making significant investments to come from behind and compete effectively with Victoria and NSW in the quest for leadership in BT and IT. It also has apparently made major efforts to attract the operational and maintenance end of the airline business in Australia, and -- with the Townsville contingent -- has a major claim on national expertise in tropical reef and coastal ocean science.

Brisbane (like Adelaide) is a pleasant, livable city, with major academic resources. Griffith and UQ each have several campuses, all located outside city center, while QUT -- Brisbane's converted technical institute (Dawkins reforms @1990) -- has its premier campus in a very pleasant setting on a peninsula that juts into the river on the south end of the city. During my visit, the Universities were busily involved in preparing their inputs into the bids for the COEs for BT and ICT. Interestingly, there seemed to be little local collaboration -- partnership if any is sought from leading contenders in other states, and State politics seems to play a quite heavy role; e.g., UQ's VC is credited with being the one who convinced the previous premier to invest in S&T (which policy is followed by the current government), while GU's incoming VC has been a major player in the present administration.

Those aspects of (hopefully) healthy competition aside, Brisbane's universities - not unlike their colleagues elsewhere in the country – do indeed have a wealth of S&T capabilities that should be of interest to ONR. Notable strengths include Asia-Pacific affairs (along with ANU), molecular biology and life sciences, environmental science, and information technologies. They also have excellent capabilities in psychology (in both GU and UQ), and as I noted in report 9B, when (if) I am able to do a more thorough job of outlining overall Australian human factors and cognitive science strengths, Brisbane will play a significant role; it should be on Yvonne Masakowski's list, along with several other cities. And, although I didn't personally see any marine technology, UQ lists it as one of its top ten strengths (and a top ten in one of the nation's 4 best universities, is very very good), and they have three island research stations, the largest number of any one organization. Thus while Brisbane is not, from our particular standpoint, a contender for siting, it should by no means be ignored when we look for collaborative partners.

B. Brisbane Visits

GU: Griffith University was established in 1974, and grew significantly via amalgamation at the time of the Dawkins reforms of the early 90's. It now has six campuses and about 23K students, of which 3400 are international (from over 70 countries; notably, there are 700 Scandinavians at the Gold Coast campus...enough, I was told, to cause some concern in their home countries) and 2800 postgraduate (1K in research degree programs). Griffith is nationally ranked, I was told,

somewhere between 8th and 13th in research; locally, Professor Lincoln placed them quite a ways behind UQ, but ahead of QUT and James Cook. A particular strength is their relations to industry; about 60% of the research income is from industry, including a major bio-prospecting contract (I visited their dedicated, high class, very automated facility with 43 staff) with AstraZeneca. Professor Linclon described GU's particular disciplinary strong points as: environmental sciences, health including molecular biotechnology (they are making a bid for the BT COE, with UNSW and Monash as possible partners; and they also have a new major Centre or Biomolecular Science and Drug Discovery to be directed by recently returned Griffith graduate Prof Mark von Itzstein, who developed the first anti-flu drug), laser physics, microelectronics, and domestic psychology, with emergent strengths in arts and music, education, and nursing. There also is a small but very successful School of Aviation that conducts pilot and aviation management training and education both in Australia and abroad; and a major thrust in PC-based, self-paced "learning centers", including one campus that has only that type of teaching. They in addition have a number of exceptional individual scientists in politics, public policy, and the humanities.

Vice Chancellor Webb (he has the longest tenure, 16 years, of any Australian VC, and will retire in January to be succeeded by Glen Davis, a Director General in the office of the Q'land Premier) had just returned from Thailand where he awarded a degree to the Crown Princess (they have also awarded honorary degrees to the King and Crown Prince). We spoke about his philosophy of international interaction, which is based upon cooperation and partnerships, as opposed to straightforward marketing and overseas campuses, or twinning. This is an important issue for Australia, since education is a $4B/year export industry, exceeding revenues from wheat. He also noted that another Griffith strength is their Adjunct faculty.

A major part of my visit comprised a seminar with several faculty members (see Itinerary for contacts). Some brief snapshots:

-The environmental science faculty is perhaps the largest such group in Australia, with close to 200 staff and over 100 PhD students. Its strength is its diversity, and it takes a very broad, multi-disciplinary approach to the study of environmental problems; the faculty contains mathematicians, sociologists, economists, etc, as well as more purely environmental (biological, physical, chemical, geological) scientists. They are involved in 7 CRCs. One particularly strong capability is in water and hydrology, and they and the CRCs get much support from the catchment authorities.

- The Software Quality Institute "works closely with industry, government, standards bodies and similar organizations internationally to improve industry's software engineering capability, software product quality and the productivity of software development" (brochure). They are the CMMI Transition Centre in the Asia-Pacific Region, as well as the SPICE Southern Asia-Pacific Technical Centre. They recently established a spin-off company, Calytrix, that (with DSTO support and a $500K federal R&D START Grant) will develop a product called SIMplicity to make it easier to develop HLA compliant simulations; they will send me further details as this product develops, and I believe that this effort will be worth following closely, given the potential importance of our interactions with AMRL's HLA-based Virtual Ship, both in S&T and FBEs. In addition, they have a procedure to define SW architectures by building a system 'out of' requirements rather than simply to satisfy them, by translating the requirements into composable form using behavior trees. If they can demonstrate that this approach would have found the problems experienced by the AP3C, then DSTO will support them for SW development of the IP3C.

- The Griffith Asia-Pacific Council boasts a substantial critical mass of academics in the humanities and social sciences, second only to the A-P program at ANU. The Council has recently been augmented by the establishment of the Griffith Asia-Pacific Research Institute. They play a substantial role in helping manage globalization and human security in the region,

including work on problems such as organized crime, terrorism, drugs and piracy. I asked for Prof Elson's prognosis on Muslim fundamentalism in the region, and he stated that the only real danger was small groups like Abu Sayeff in The Philippines, that are basically criminal with no political agenda. He was not however complimentary regarding the PM's appreciation for the workings of polity in Indonesia. He also expressed the opinion that multilateralism is an inevitable trend; the times are simply too troubled for isolation or bilateralism. Although we did not have long to talk, my sense is that this group, together with their counterparts at ANU, could contribute substantially, in both an intellectual and experiential sense, to the augmentation of CINCPAC engagement strategies. I believe such interaction is worth consideration by J4 and J5.
- The School of Engineering is located on the Gold Coast Campus, and has a substantial interest in 'vertical cities' and the structural engineering aspects of super high-rise buildings. They also have a coastal engineering program, that includes studies of sediment transport and wave/seabed interaction. They had been visited by IFO's CDR Butler.
- Prof Standage, a laser physicist and Pro-VC, commented on additional strengths of the University. They are a key node of the CRC for Micro-technology, with capabilities for large scale IC design. They have strengths in laser physics and surface science, and a scanning AFM is shared by the physical and biological researchers. They also have Australia's largest complement of psychologists, with schools of applied psychology both in Brisbane and the Gold Coast. He noted that the State has been extremely supportive, and has a large number of initiatives to make Queensland the "Smart State". Much of the planning and coordination for these initiatives has been done under the direction of their incoming VC.

Prof Lincoln escorted me on a visit to the bio-prospecting lab that works under contract for AstroZeneca. Their research extends from collection in the rainforests and reefs (subcontracted to the museum and similar groups), to thorough chemical and biological analysis that has identified over 600 new potentially useful new compounds. The staff consists of a large number of PhDs with highly qualified lab assistants, and after several years of development, their modern and secure labs appeared to me to be world class, well designed for both very high quality analysis and rapid throughput. At the time of my visit, a State government delegation was meeting with their Director to discuss GU's bid for the new BT COE.

UQ: The University of Queensland is this state's member of the Group of 8, and indeed is among the nation's few most highly ranked research universities. It has some 32K students, of which about 3K are postgraduate (they want to push the PG program up to 25% of enrollment) and a similar number international (half of these are PG). It belongs to 19 CRCs, and hosts the Special Centre for SW Verification Research (see below) and Key Centre for Human Factors and Applied Psychology (which I missed but should be on the list for Yvonne Masakowski's visit which I am ever more convinced is important). Like many other Australian Universities UQ looks at international, fee-paying students as an important source of income; and in UQ's case, they have a significant contingent of Americans, many (almost a thousand at any time) on study-abroad semesters. My visit comprised discussions with Pro and Deputy VCs and senior research managers, a meeting with the UQ-hosted CRC for Enterprise Distributed Systems Technology (DSTC -- to which I was directed by DSTO), and discussions with representatives from the Faculties of Health Sciences, and Engineering, Physical Sciences and Architecture.

Pro VC David Siddle (until recently at U Sydney) noted that the academic and research environment is so competitive that even the best Universities need to focus on, and build to, their strengths. In UQ's case their major strength and international reputation is in molecular biology and life sciences, and they are in a major joint venture with CSIRO to construct a new world class research facility, of which their portion will be called the Institute for Molecular Biosience. One of the State's initiatives is in nanoscience, and should UQ participate, that also would feature biology. Other strengths include physics (laser physics, quantum computing), and some aspects

of social sciences including psychology where they have institutional, plus student and faculty exchange, research links with Princeton. Their agriculture and veterinarian groups are heavily supported by international organizations for work in underdeveloped nations in the region. Marine science is also among their 'top 10' areas, and they have three island research stations in the reef area (the University of Sydney, Queensland Museum, and James Cook also have island stations, which are operated collaboratively through the Tropical Marine Network -- see the Townsville Sections).

One of UQ's challenges is building interdisciplinary teams across traditional academic structures, and they (like others) use techniques like Institutes and Centres, e.g. linking ag and vets into molecular bio-sciences. In part this is driven by the 'rules of the game', since more and more federal programs are looking for institutional based bids for large programs (like the BT COE, for which they will be a significant part of Q's bid). Another challenge is spin-offs and tech transfer. They established Uniquest about 10 years ago to manage their intellectual property, and recently established Uniseed as a joint venture with the University of Melbourne (CSIRO is expected to join) to create a pre-seed funding mechanism. They already have some 24 BT spin-offs on campus, and badly need a campus-based incubator.

It was the UQ VC John Hay who initially persuaded the State government to invest in S&T; this policy now has bipartisan support. Previously Queensland's economy was based largely on commodities (with little if any value-added), and tourism, which is susceptible to uncontrollable external forces (e.g., the Asian financial crisis, now terrorism). They also had a massive influx of people from the southern states (sort of the US inverted), providing a consumer-driven base. Such trends convinced the state it had to be 'smarter' -- thus the Smart State motto -- and it indeed has invested in S&T, albeit with clear but achievable metrics (e.g., jobs in the state) in a performance-driven manner, with expectations that the University or industry partner will bring cash as well as kind to the table, and generally in areas where other resources such as federal programs were unavailable. Thus while the State has been a good partner for S&T (not all my University contacts agreed that the actual dollars matched the political rhetoric), there are constraints because of the number and geographic distribution of institutions. The challenge is to devise a mechanism that spreads the opportunities, while still building critical mass and centers of excellence (such problems were reflected in conversations at James Cook University in Townsville, where VC Mouldin commended UQ for its role in prompting State support of S&T, but noted that most of the money stayed in Brisbane).

Some notes from discussions with faculty of EPSA and Health Sciences:

- UQ's Faculty of Engineering, Physical Sciences and Architecture has Schools of Engineering, IT&EE, Physical Science, and Geography, Architecture and Planning, as well as a large number of faculty Research Centres, and participates in a dozen cooperative and special research centres. IT&EE (formed by amalgamation of two departments in 1997, and initially named Computer Science and EE) has some 2000 undergraduates, over 130 PhD research students, 60 faculty and over 200 research staff including the centres. Given its size and breadth, it has a very wide range of research interests, from robotics to signal processing, computing, and human factors. Research sponsors include DSTO, ABB, BaE, DARPA, GEC, NASA, Oracle, SW Engineering Australia and Sun Microsystems. They host DSTC, and have a strong role in CSSIP (See Report 9B). They with DSTC will host a DARPA sponsored workshop on Complex and Dynamic Systems Architecture, 12-14 December (see http://cdsa.dstc.edu.au; this appears to have significant US participation, so in spite of ONR interest in the topic, IFO presence isn't essential).
- The Software Verification Research Centre was established as an ARC Special Research Centre in 1991, and is now totally reliant on industry support. My briefer Prof Peter Lindsay stated that the transition was hard, but that their business plan seems to be holding up ($2.3M turnover in 2000, 20+ full time staff plus academics and students); one change is that their projects tend to be more short term. They specialize in safety critical systems, hazard and risk analysis, and IV&V,

as well as SW engineering and modeling and analysis. They have supported over 30 DMO projects, as well as helped develop policy and guidance for defence systems. Of particular interest, they ran a very extensive safety program for Australia's version of NULKA.
- Earth Systems Science research at UQ focuses on hydrothermal ore deposits and coal and coal seam gases (methane production, CO2 sequestration), as well as continental and marine geological evolution and change. The Department has excellent isotope dating labs. One of their recent major discoveries was the Woodleigh impact structure, dated to the late Devonian; it is the largest of a Late Devonian impact cluster that includes Charlevoix, Canada and Siljan, Sweden, and was a major contributor to the period's mass extinction of regose corals, trilobites, brachiopods and fish.
- The Faculty of Health Sciences has programs in dental sciences, human movement (exercise science and education), indigenous health, medicine and surgery (preparatory; their medical degree is postgraduate as in the US. A four year graduate entry medical course, for which applicants must have completed a bachelor's degree, has completely supplanted the 'six year school-leavers entry' course), occupational therapy, oral health, pharmacology, physiotherapy, and speech pathology. For postgraduate studies, it is closely aligned with the Queensland Institute of Medical Research, which has a new cancer center and is adjacent to the UQ medical School and near the Royal Brisbane Hospital and the Royal Childrens' Hospital. They are shortlisted for the competition or the new Centre for Military Medicine (see Report 8), but note that it is not completely clear what DOD really wants from this new Centre. They do know that DOD Health is interested in linkages, and they are close to the Queensland based Army Malaria Research Unit but also desirous of formal connections with international groups. I referred them to NMRU and AFRIMS. Another new initiative is the Centre for Complementary and Natural Therapies (a $B industry in Australia). Research strengths include cancer, population health, tropical and EID, malaria, parisitology, immunology, pharmaceuticals and drug delivery. Under pressure to form larger groups and couple their strengths to other fields, they are finding that many areas of clinical medicine could benefit from the basic sciences, but also that they can contribute strongly to initiatives in fields such as nano-science through applied bio-materials. Many of their scientists are of international stature, including Prof John MacKenzie who is currently Secretary General of the International Union of Microbiology, and has strong links with CDC and other US EID researchers, including those at NMRU Jakarta. He is leading the development of a bid for a CRC for EID. If indeed ONR and other US research sponsors accept my proposition that participation in Australian CRCs is a sound investment strategy, this could be an exceptional opportunity to relatively inexpensively couple GEIS and other US initiatives and interests to an extremely strong and talented Australian-based EID team. Although medicine is not an IFO focal area, recent events (and my own experiences over the last couple years) convince me that a significant US multi-agency participation in this Australian-led bid could make a major long term difference in an area of great mutual interest. I commend this to Miriam Baltuck's attention.

QUT: Queensland University of Technology is one of the 'new' universities, created by transformation of a former technology institute and amalgamation around 1990. With three campuses (including its main Garden Point Campus located right next to the Botanical Gardens in Brisbane's City Center), 30K+ students (3500 international, 1K research MS & PhD), and over 3000 staff, it retains its tradition of close ties to industry, and advertises itself as the 'university for the real world'. ProVC Gardiner (a lawyer) noted that their consolidation has gone more smoothly than many; and as one next step in the long, slow process of development of excellence, QUT and its counterparts (UTS, RMIT, USA and Curtin) have formed the "Australian Technology Network", sort of a counterpart to the Group of Eight, the well established consortium of the old, leading research universities (he noted that they actually divided into two

classes, since of the 70% of research funding accrued by the eight, the top 4 accounted for 46%). QUT actually did rather well in the last ARC round, ranking 8th in linkage grants, and climbing to 13th in discovery grants.

With its focus on industrially oriented education, QUT has arranged its faculties in a somewhat different fashion than many others. For example, instead of humanities and arts, there is a Faculty of Creative Industries. There is also a Faculty of Information Technology, where I spent much of my visit (IT seems to provide for QUT the same sort of coordinating focus as biology at UQ, albeit they are still struggling to develop research linkages where neither partner looks at the other as simply a service or content provider), and one of the Built Environment and Engineering, as well as Business, Law, Education (where they are strong, producing most of the teachers in Queensland), Science, and Health. Their bent to practicality and IT is demonstrated by the use of an electronic 'mock court' in law, and management of the State's back-up stock exchange as part of their business education program. Consolidation as in the case of IT helps develop critical mass and interaction among various related disciplines, and is one of a variety of mechanisms they are using to stimulate cross-disciplinary strength. I was told that for the first decade, in order to build research strength, they stressed 'vertical' centres, within disciplines. Now they seek to combine these strengths 'horizontally' (n.b. this same trend at UQ, in spite of its maturity).

QUT is in 7 CRCs and is lead site for two. Prof Gardiner is a self-professed cynic regarding the CRCs, noting that they have not achieved the expected degree of commercialization for which they were intended, frequently do not develop a critical mass but rather are simply a pot of combined funds over which the participants squabble, and can deprive the universities of the attention of staff and considerable IP. QUT's relationships with CSIRO labs range from positive to negative, but the new Director Geoff Garrett is working hard at reprioritizing and focusing its efforts, and working more cooperatively with Universities. The State is serious about its Smart State thrust, albeit Queensland is not yet a powerhouse like NSW or Victoria. The $100M proposed for initiatives can get readily drained away, and the required commitment by the Universities causes a strain on resources that are hard to accrue (the main source being fee paying students from abroad). In nano-science for example the government's $4M/year for 5 years is supposed to be matched by them in cash as well as kind. While there are not a lot of clear state government priorities, one main one is aviation; Boeing and Virgin Blue have their headquarters in Brisbane, and the state is working to get Quantas to move its maintenance operations to the area. QUT itself is considering CRC bids in transport and avionics.

The Centre in Statistical Science and Industrial Mathematics is quite a strong group, with 10 research academics and 12 PostDocs, 23 PhD and 6 research MS students. I had asked to visit them because Prof Tony Pettitt has been on the ARC panel for math and information sciences. He noted what I consider to be an interesting anomaly, namely that on an international basis Australia is extremely strong in math research, weak in info sciences (people either leave or go into business), whereas the student attraction is in the opposite direction. One of his group's strengths is his own field of applied statistics, and we discussed some of their work in fisheries, and -- by Prof Vo Anh -- GIS for modeling and analysis of multi-scale remote sensing data, with application to detection of changes in vegetation and desertification of northern China (sponsored by the Hong Kong Research Grants Council; this work may be of some interest to MEDEA). They also have groups in industrial modeling (mathematical modeling of industrial processes), operations research, and medicine and biology (e.g., migration of cells in multicell tumor spheroids, with colleagues in the UK). Like many other groups, they have well designed brochures to advertise their skills and attract support and students.

The Faculty of IT is a large and powerful group, with 3 schools, 5 research centers, 120 faculty, and some 2.5K+ students, with the international contingent doubling every year. Like the rest of the University, they have a very applied focus. My hosts were Bihn Pham, Director of

Research who formerly was a research fellow at ANU, then IBM Professor at first Monash, then Ballarat (as part of an experiment in moving education away from the main cities); and Prof Ed Dawson, Director of the Information Security Research Centre (and a transplanted American from UW). The Head of Faculty, John Gough, was in US to lecture on the new book he had just written at the request of Microsoft, on ".NET" programming. Following discussions and lunch with them I was briefed by each of the IT research centres.

- The Cooperative Information Systems Research Centre (Prof Arthur ter Hofstede) researches workflow, electronic services, and associated web technologies. They have two main ARC SPIRT projects, one with the Global Banking Security Transactions (GBST) on 'self-describing transactions (e.g., trading, negotiations) in an open heterogeneous and distributed environment", and the other with Mincom on architectures for 'open distributed enterprise system management with configurable workflow support'. One of their basic areas of concern is the proliferation of workflow systems and the failure of WfMC standards due to semantic confusion; their approach focuses on 'expressive power' and suitability.
- The Information Systems Management Research Centre (Prof Guy Gable) is business and management oriented, with research themes in IT governance, Information Governance, IT implementation, and IT education and professions. It has focused on collaborative (SPIRT and linkage) grants with industry and has several projects dealing with enterprise systems and ERP. It is also the mySAP.com Australian Hosting Centre, supplying access to SAP R/3 and SAP e-business software to Australian and NZ universities.
- The Information Security Research Centre (ISRC) is the largest and strongest group, formed in 1988. It has 20 academic and 6 full time technical staff, with 28 PhD students. The founding Director, Bill Caelli, is now Head of the School of Data Communications, and heavily involved in security policy related issues both in Australia and internationally. The Centre does both applied and pure research in four groups: Cryptology (Ed Dawson; one of their products, "Cryptex", which was developed under an ARC grant, analyzes cryptological algorithms and has been sold in 20 countries), Network and Systems Security (Prof Mark Looi; firewalls for all Queensland government depts, smart cards, network management, and recently computer forensics with DSTO), Security Policy and Risk Assessment (Bill Caelli; digital signature policy, security policy, risk assessment, legal and regulatory issues), and Secure Electronic Commerce (Prof Colin Boyd; payment and voting schemes, public key infrastructures, compliant cryptogtaphy). ISRC does considerable work internationally, notably in Hong Kong and the US, and has a large number of international and Australian research partners.
- The Programming Languages and Systems Research Centre (Assoc Prof Paul Roe) does technical, in many cases traditional, computing science research. It has developed "Gardens Component Pascal", with implementations for the Java Virtual Machine and Microsoft .NET Common Language Runtime, and led to John Gough's new book, "Compiling for the .NET Common Language Runtime". It also researches next generation web services, and is developing Gardens 2, a generalized framework for 'cycle stealing' across the internet (like SETI@Home).
- The Smart Devices Lab (Dr Jim Hogan; Dir Prof Jaoquin Sitte) -- not yet a Centre (They have Centres at School, Faculty and University levels) -- is working on devices that couple people to real or virtual environments through adaptation and decision making. They use small autonomous robots as targets and models (robot soccer is big in Australia). Research includes insect vision for selective vision and object recognition, machine learning algorithms, and 'local cluster neural nets for real time control applications.

DSTC: The CRC for Enterprise Distributed Systems Technology, headquartered at UQ, develops "methods and technologies to establish and evolve the IT infrastructure and associated work practices for distributed enterprises". It was established in 1992, and was awarded its second 7-year funding ($20M federal, with ~$100M from some 20 University, government, and industry

participants) in 1999. I met with its Research Director, Prof Melfyn Lloyd, and Principal Scientist Prof Simon Kaplan (also Head of the School of IT & EE at UQ). It is somewhat different from some of the other CRCs I visited in employing its own large staff (~140) as well as ~35 seconded from industry and academia, and advertises itself as 'a company whose business is research', with annual revenues of the order of $5M. It recently established a spin-off company, Wedgetail Communications, which has a suite of cryptographic and authentication products designed specifically for Java and networked/wireless devices; much of its business is expected to be in the US. DSTC has done considerable work for both NSA (e.g., information analysis and the semantic web) and DSD, as well as DSTO, and is in discussions with DIO and DMO. Its key industrial targets include government on-line services, defense, health, education, and advanced telecommunication services. Its construct of an enterprise is an evolving system in a plastic environment with emergent properties, that needs to 'embrace change in the midst of integration and interoperability'. Its research programs cover Knowledge and Resource Management, Component System Engineering, Organizational Policies and Security, Enterprise Modeling, and Enterprise Processes and Work Practice. If Peter Majumdar does get stationed in Melbourne, it would be desirable to find out more about DSTC's operations and work for Australian DOD.

C. Townsville Observations

Reef City!! While Cairns has surpassed Townsville for the reef tourist trade, Townsville retains its Australian -- if not world -- preeminence in tropical marine research, with a natural focus on the Great Barrier Reef. The city's University, James Cook (which has a Cairns campus as well), does indeed have a standard full-scope teaching program, but it -- like the Australian Institute for Marine Science (a statutorily established independent research institute that reports to DISR), and the regional museum (which is super!), and of course the CRC Reef and the Marine Park Authority -- clearly bases its international reputation on tropical environmental science, and more particularly on those aspects of land, water, and human activity that influence or are affected by the GBR (the Park area includes many working ports and cities, as well as the mouths of rivers that variously pass through rainforest and farm land). To round out the environmental research opportunities, the area also boasts world heritage tropical rainforests, and tropical savanna. In addition to its research, between the casino, the huge reef aquarium (Reef HQ), a number of tour boats, and some excellent restaurants, Townsville also does a modicum of tourist business; and it is a major port, servicing the local mining (silver, copper, nickel, and enormous phosphate deposits) and agricultural industries. With such diversity, the local economy promises to remain robust.

One very pleasant feature of Townsville (and contrast to Brisbane) is that the research-oriented organizations work very closely together. Dr Baltuck and I visited all of them, and they unanimously spoke highly of the others' skills, which indeed seem to blend nicely. This collaborative environment is a bit unusual from what I've seen in the bigger cities, and perhaps it can be best explained by a combination of their fundamental focus on a common local feature of world importance, and their relatively isolated location. One potential irritant was recently removed when CSIRO's takeover bid for AIMS (instigated by its previous Director, Malcolm McIntosh) was soundly rejected (of course not in so many words) by DISR Chief Scientist Robin Battingham's report on his (bid inspired) review of the status of Australian tropical reef science; his conclusions should put to rest, at least for a while, the past history of 'land grabs' (water grabs?) that have at various times in the past gone in both directions (Footnote: Both Nan Bray of CSIRO Marine Research and Stephen Hall of AIMS profess close relationships with each other, personally and institutionally; the turf fights were before their time, or of others' making. I will

leave my personal comments on this division of responsibilities to my future report on Australia's innovation system).

For the purposes of this report, suffice it to say that if ONR or any other US sponsor has interest in tropical littoral marine science, Townsville is a critical node that absolutely can not be ignored. The scientists are world class in their fields, and therefore well connected with the international community. They have many close US collaborators, and continue to offer access to the GBR through their research facilities, either directly or through the various island stations (operated by a number of Universities and other institutions) whose activities are coordinated by the Tropical Marine Network. It is important to note that the topic of tropical reef-related research must be construed very broadly, from anti-fouling products and other results of bio-prospecting, to geomorphology, nested coupled ocean-atmospheric modeling in a complex littoral environment, fisheries, and both the science and the sociology of naval activity (civil and military) in an environment of significant popular concern. And, Reef Hq and the Museum of Tropical Queensland should be must-stops on any visit to Townsville, for their research contributions no less than for the quality of their public exhibits.

D. Townsville Visits. Dr Baltuck accompanied me on all visits, and will be drafting a cable about Australian reef conservation efforts, so my comments will (for a pleasant change) be brief.

JCU: James Cook University is a relatively small (~8500 students) regional university, established in the 1960's and servicing the Cairns and Townsville regions of Queensland. It also just happens to be sited at the edge of one of the world's greatest littoral marine 'natural wonder' sites, and on the land side is backed by exceptional rainforests and savanna. It has taken advantage of those environments to build a truly world class environmental program that spans the range of tropical ecosystems and associated disciplines, explicitly including the human and economic dimensions. Its niche expertise is demonstrated by its 38% success rate in the last ARC round.

Dr Baltuck and I had very enjoyable and informative conversations with the VC and Pro-VC (Research), spent considerable time with the Director of the School of Marine Biology and Aquaculture (and toured their facilities), lunched with faculty from diverse professions, and were briefed by the School of Tropical Environment Studies and Geography (TESAG), and representatives from Math/Physics, IT, engineering, and earth sciences. So in addition to our in depth discussions on our central topic of interest, reef research and conservation, we saw several other aspects of their expertise. One thing we did not get a chance to see is their medical research, but it was impossible to avoid the under-construction Queensland Institute of Medical Research that abuts the JCU campus and the local Children's Hospital. If I was to pick the two points of most interest from our discussions with Profs Moultin and Palmer (VC, ProVC), they would be the degree of cooperation among Townsville marine researchers, and some of the deficiencies in state and federal support of education and research (e.g., Q$ tends to stay in Brisbane...lack of sound federal policy on education and associated research).

The School of Marine Biology and Aquaculture, headed by fisheries biologist Prof Mike Kingsford who recently came to JCU from U Sydney, has 19 academic staff, 5 postdoctoral fellows, 112 PG students (of which some 45% are full fee paying, with many from the US and UK) and 174 full time undergraduates. Prof Terry Hughes of the School, who has spent much of his research career in the States, was recently elected to the Australian Academy of Science. Research topics in marine biology include coral and coral reef ecology, marine conservation and the detection of biological change, reef fish and tropical fisheries biology, and coastal, estuarine, and invertebrate biology. They also work through the CRC Reef to assess invasive species in the area (ballast water is a major concern). Aquaculture programs focus on species of significant or

potential commercial importance but low environmental impact, either for Australia or for the underdeveloped island nations, such as rock lobster, pearl oysters, crayfish, or barramundi (a large, voracious fresh water game and food fish, which I found to be very tasty).

TESAG is split between the Cairns and Townsville campuses. It has about 16 academic staff and 140 PG and honors students. Its is very multidisciplinary, with expertise in human and physical geography and geomorphology, spatial analysis (including GIS and remote sensing), tropical environment studies and natural resource management. We spent considerable time discussing recent research findings about the frequency and severity of natural hazards based on anaysis of coral shingle ridges and other landscape features.

From our other discussions: The Townsville IT group has recently decided to focus its research efforts on bio-informatics, especially protein structures, and to align themselves closely with a new product discovery group being formed in collaboration with ANU. Like many others they see the product development potential of the area as unmatched. The math and physics school , with about 15 academic staff, includes computational math and modeling, physical oceanography and meteorology; statistics and data analysis are growth areas. They do of course teach the basics, both for their own students and as service to the rest of the university. We saw several examples of their meteorological and oceanographic instrument development, including turbidity sensors, and backscatter radars operating at 30 & 150 MHz. Environmental Science has 13 staff, a half-dozen post-docs, and 60 PhD students; they work in economics and geology, tectonics, and marine processes, with particular interest in the local margin, and have had long experience with ODP. They operate a trawler-sized research vessel, supported through contract work. Assoc. Prof Hardy of Engineering has a particular interest in waves and coral reefs. He and his colleagues have developed a cyclone wave data base for the GBR, and are now starting to model non-cyclonic winds and waves that, while less strong, are more persistent and of significant interest to the tourism and fisheries industries. They also have provided a storm surge model to BOM, and hope for a contract to model wave setup. Dr Kessissoglou and her student, with industry (NQEA) and DSTO, are researching noise and vibration signatures of ship structures; their particular interest is attenuation of the structural and acoustic responses associated with coupled beam and plate structures submerged in a fluid.

AIMS: The Australian Institute for Marine Science is an independent Statutory Authority reporting to DISR, "the only science agency wholly committed to the conduct of marine science in the national interest" (Research Plan, 2000-2003). Like CSIRO, it is funded on a triennial basis, which allows for relatively firm planning. Perhaps the major recent event in its history is the release of ISR Chief Scientist Robin Battingham's report on the status of tropical reef research in Australia, which concludes that AIMS should maintain its independent status (i.e., not merge with CSIRO Marine). In addition, AIMS will increase the size of its contingent in Dampier, Western Australia, with a focus on the reefs and oil and gas bearing shelf areas in the region, and substantial additional support will be provided to the network of reef island stations. In addition, in the recent MNRF competition, ANU, AIMS won a A$3.25M grant to establish a major new Arafura-Timor Research Facility in Darwin, on the campus of ANU's North Australia Research Unit (located adjacent to the Northern Territory University). The mission of the A-TRF is to "facilitate the strategic commercialization, sustainable management and appropriate conservation of the marine and coastal ecosystems of the Arafura and Timor Seas for Australia and for our regional neighbors".

Dr Baltuck and I had extensive conversations with Director Hall both at AIMS and later over dinner, and were led on a tour and set of briefings about their programs by Research Director Peter Doherty. One of the most interesting new facts we learned is that over 60% of the world's coral reefs are located deeper than 30M; like (I'd assume) many others, we had both pictured the shallow reefs as being predominant. Because AIMS is so well known

internationally, I will simply note here that AIMS operates two coastal (27.4m and 20.7m) research vessels, (their support services department has an annual budget of about $13.7M), coordinates very well with its colleagues in Townsville and the rest of the Australian and international tropical marine community, (including CSIRO...the recent take-over bid was led by the now deceased former CSIRO Director), and sees its clients as "the Australian community, marine industries, regulators and governments, policy developers, other researchers, educators and students", and for 2000-2003 has a well defined research program in five areas[157]:
- Predicting climate impacts upon marine ecosystems (Eric Wolanski) with "key result areas" of coral reefs and climate change, terrestrial run-off into coastal receiving areas, transport models for water, sediments and propagules, and the biological oceanography of the (poorly described) North West Shelf (2000-1 appropriations of ~A$2.7M, + $390K contracts) - Exploring and conserving marine biodiversity (Andrew Heyward), key result areas: resource surveys for regional marine planning (in support of the Ocean Policy), sea floor bio-diversity, population genetics and marine protected areas, evolution and bio-geography of marine biota, and the Global Coral Reef Monitoring Network (which is coordinated by AIMS scientist Clive Wilkinson) (~A$1.3N + $800K contract)
- Sustaining marine living resources (Terry Done): status and trends of coral reefs, fish population dynamics, and decision support for marine resource managers (~$2M + 635K contract)
- Measuring Human impacts in Coastal Marine Ecosystems (Daniel Alongi): biological impacts of excess nutrients in marine ecosystems, bio-indicators of sub-lethal stress in marine organisms, biochemistry of estuaries, and human impacts on Ord-Bonaparte (a tropical macrotidal estuary in the Kimberly region of WA) ecosystems ($2.6M, $400K contract)
- Deriving benefit from marine biotechnology (Chris Battershill): tropical aquaculture (with a focus on the black tiger prawn, Penaeus monodon; in addition to disease problems, the aquaculture industry relies on wild stock for breeding, and cuts off the females' eyestalks to induce hormonal change and increase spawning. A major goal is therefore to improve breeding from pond reared broodstock), bio-active molecules from the marine environment (using their ecological and biological expertise for targeted prospecting), and marine environmental biochemistry and chemical ecology ($1.9M, + $20K contract)

Museum of Tropical Queensland: I found this regional museum to be a marvel of its class. The Director Carden Wallace hosted us for lunch, took us on a tour of the research and conservation facilities, and provided us a guided tour of the public exhibits. There are two principal exhibit sections. One features *HMS Pandora*, the frigate the British Admiralty sent to find the *Bounty* mutineers and bring them back to justice. *Pandora* struck the GBR and sank in 1791, and is today an archaeological treasure house because of the precise knowledge available about its voluminous stores (it carried enough to re-provision *Bounty* and sail her home), manning (including some captured 'mutineers') and layout (artifacts can be precisely prescribed), as well as its location in 33M of water under 2M or so of sand, which has prevented earlier pillaging and beautifully preserved much of the material. The Museum, with financial backing of the Pandora Foundation, has run some 8 archaeological expeditions to the ship, and has an exceptional collection of artifacts, many of which are very professionally displayed. The second major display section is 'Discover Tropical Queensland', which provides an in-depth perspective on the peoples and environment of the region. The museum also has a student-oriented sciences center, and a revolving display area which during our visit has a Federation centennial exhibit from the War Memorial in Canberra.

[157]Also of note are the many publications of AIMS researchers, notably including J.E.N. Vernon and Mary Stafford-Smith's definitive, 3-volume *Corals of the World* (AIMS; ISBNs 0 642- 32236 8,32237 6, and 32238 4, and Eric Wolanski's recent *Oceanographic Processes of Coral Reefs: Physical and Biological Links in the Great Barrier Reef* (CRC Press, ISBN 084930833X).

The museum plays an important role in the research community in the region. In addition to its marine archaeology and conservation programs, museum scientists do biological research wth JCU and AIMS staff; and Dr Wallace is a world class expert on staghorn corals. She is a renowned taxonomist (and a colleague of close friends of mine from WHOI), and the Museum's research coral collection is exceptional. During our visit, Dr Wallace was training two Indian taxonomists who will in turn train other Indian scientists upon their return to their institutions.

GBRMPA: The Great Barrier Reef Marine Park Authority is basically a regulatory agency, responsible for the very wide range of commercial, recreational, and research activity within the World Heritage Area. We met with Chair the Hon. Virginia Chadwick, the two Executive Directors John Tanzer and Gregor Manson, and Research and Monitoring Coordinator David Wachenfeld. GBRMPA and its activities are quite familiar to NOAA, with whom they have joint research programs (involving AIMS and JCU scientists) on the link between ocean temperatures and coral bleaching. GBRMPA obtains all the research they need via the CRC; and they have a very well defined strategic list of some 300+ research requirements, worked out through interaction with users and scientists. In addition to the normal challenges associated with sustainable management of a huge marine ecosystem that is simultaneously of immense cultural and biological value, heavily traversed and exploited commercially (2780 licensed master fishers and >600 tourist operators, plus major ports and shipping channels), and significantly impacted by terrestrial activity, they are faced with the growing issue of bio-prospecting. Chair Chadwick indicated that they had no clear policy on that issue, and that although all collecting is done under permit, end uses of the collected specimens is not within their jurisdiction.

Following our discussions, we had a behind-the-scene's tour of Reef HQ, Townsville's very large, outdoor reef aquarium, and one of the area's principal tourist attractions. The aquarium is some 15 years old and will soon be refurbished, and because of its size and the influence of the local environment (rain, evaporation, etc) offers some very interesting challenges in maintaining the quality of the ecosystem. Although principally a tourist attraction, the aquarium does provide an excellent research environment, and the staff themselves do considerable applied research on water quality, coral sustainability and propagation, and dynamics of flow in their very large tank; they have a precisely controllable wave generator, and the Director suggested that flow around their reef under various wave conditions would make an interesting PhD topic.

CRC Reef: The CRC for the Great Barrier Reef World Heritage Area was renewed two years ago. It is a 'company limited by guarantee', and its members are the Association of Marine Park Tourism Operators, AIMS, GBRMPA, JCU, Sunfish Queensland, Inc, the Queensland Dept of Primary Industries, and the Queensland Seafood Industry Association. It provides a major linkage mechanism among the various parties concerned with reef business, sustainment and research, and as typical of CRCs, also is active in education, supporting some 80 graduate students. Its research programs are categorized as Management for Sustainability (social, cultural, and economic values; decision support for managers; informing the management process), Sustainable Industries (ports and shipping; sustainable tourism; innovative engineering; fishing and fisheries), Maintaining Ecosystem Quality (conserving bio-diversity, assessing land-based threats and impacts), and Information Systems and Synthesis. During its first round the CRC served principally as a granting body, but during this period it advertises itself a knowledge broker and facilitator, and with a small staff (8) basically 'sells' its skills in project management to its members and other clients, including international organizations.

CRC Reef's CEO Russell Reichelt was formerly Director of AIMS. He is also very active in many other aspects of Australian marine policy and research, including chairmanship of the National Ocean Advisory Group, which 'packages problems and gives the government early

warning'. He has recently established the GBR Research Foundation to tap into international philanthropy, which to date has raised over $20M in pledges. The foundation's goals are the sustainability of reefs worldwide. He is also promoting a regional network through APEC, and has discussed his ideas with many US agencies including DOS; common themes are the benefits of collaboration and capacity building in areas of shared problems. The CRC also has formed a spin-off company, International Marine Projects Activity Centre (IMPAC) in Townsville, to encourage coordinated communications and infrastructure on the reef and in the region.

E. Comments and Recommendations

I find at this point (my third report on this country), that there is not much new left for me to say about ONR's proposed interactions with Australia. Simply put, we have done enough minor trolling in these waters, and it is time to get serious. With in-country presence (Dr Baltuck and hopefully Dr Majumdar), future IFO visits should be targeted to well scoped opportunities, and should preferably feature corporate leadership, or better yet the POs who are ultimately the investment decision makers. This is particularly true in the disciplines of our postulated reps (whose expertise in my opinion fully covers ONR 32, 33, 341, and 36, and provides significant input to 31 and parts of 35). The only field where I believe further in-depth scoping by an IFO expert is warranted is psychology/physiology, writ large (cognitive and neural science, neuromorphics, biomimetics, learning, decision making, machine intelligence). I have in my various Australia reports suggested that a relatively intensive visit by Dr Masakowski or someone else with her talents (or someone like Joel Davis from the cognitive science perspective) would be very beneficial; but otherwise, our focus needs to be on productivity and Command level interaction, not occasional pass-bys, bush trip extensions, or scoping studies.

This report focuses on Queensland, interestingly the only State where I have visited two well separated centres of interest to us. With no disrespect intended, Brisbane may be classified as 'more of the same' (i.e., a lot of very promising collaborative opportunities and some highly capable, world class researchers; and the IFO should as usual read my detailed visits section for suggestions for follow-up) as well as a real 'comer' in competition for future Australian strengths. Townsville however already is in a class by itself with respect to its specialty, tropical littoral and reef ocean science. While NOAA and NSF are the logical agencies for primary US institutional interest in Townsvilles' institutes' research, to the degree that Navy needs to work in warm waters, or that USN vessels may need to sail near or among reefs, we should be familiar with their work.

As a closing comment on Australia, I should note that I have visited only the south, and even there had quite a light touch. I have missed Darwin which has great international importance for environmental S&T, the northwest which is of significant interest for operational T&E and experimentation, and the 'red centre' with its space-oriented and OTH radar facilities. I deliberately bypassed (in favor of the F. E. Saalfeld trip which was subsequently cancelled) several of the top Universities (e.g., UNSW, U Melbourne). I also intentionally avoided many spots which have been extensively reviewed by other US scientists and engineers (e.g. the DSTO MCM lab in Sydney, and the shipyards of Tenix, ASC, Incat, and Austal), as well as the major internationals (e.g., Boeing, Thompson, BaE, etc., which are able to make a huge difference in the country's innovation if they want to [the exception is Motorola which has been extremely active in exploiting Australian S&T and with which I met in both Perth and Sydney]). I have also been selective in visiting SMEs (I only saw good ones).

Because as a geographer I couldn't resist the opportunity to travel as much as possible on the ground, I had only limited time in the intellectual centers; and since I had to travel fast to get to

the next stop, neither did I do the countryside and its resources justice. But then, I was trying to do in 6 weeks, what I had planned for two years. Hopefully I have touched at least enough bases to understand ONR's past mistakes in trying to establish our office, and enough others to justify fully a resubmission of the NSDD 38; given the fact that I have missed many of the previously acknowledged 'hot spots' for ONR and DOD interest, my enthusiasm over the opportunities for leverage, and the importance of in-depth collaboration at this time in submarine matters, should have even more weight than normal. At a minimum, I would argue that anyone who wishes to comment on or criticize our reapplication should be forced to read these reports, understand the relevance of what I have identified to our major interactions in submarines and ships (fast ferries) and other naval warfare areas, and argue their case on the merits.

Thus in sum:
- We have a growing naval strategic relationship with this nation that should be nurtured through informed US pro-activity in areas that matter the most to both of us, starting with (and extending from) submarine technologies.
- The S&T base in Australia -- with all its warts -- offers exceptional opportunity for ONR-sponsored collaboration, and for leverage (e.g. CRC participation), and in addition must be followed closely (strategic surprise at issue here) because of Australia's leading position in some critical future areas of technology (e.g., quantum computing, robotics and biomimetics; they are determined not to miss the next IT [or BT] revolution, and I think they're on track...). Also because of Australia's outreach in research and education to other nations of the region (island states, ASEAN, Asia).
- Even leaving aside geopolitics, the nexus of Singapore-New Delhi-Canberra (and Pretoria...) envelops ocean areas of critical importance to the US, for commerce, freedom of navigation, anti-drug/piracy, humanitarian assistance and disaster management, access to littoral hot spots, natural resources, and climate change. Our Australian strategy should, via CINCPAC and DOS, couple our Australian initiatives to the region.
- We are exceedingly lucky in having two individuals -- Drs Majumdar and Baltuck, one proposed and one in place -- who as ONR representatives would have not only the right technical talents, but even more importantly the respect and admiration of their Australian counterparts that are prerequisites to effective and efficient collaboration. We also have ready access if we want it to consultants with excellent connections to those industries, small and large, that will lead Australia's Defence developments; such local expertise can be invaluable. Admittedly, this combination of talents significantly challenges the traditional US EST/ODC approach to US international dealings in the S&T, strategy, and policy areas with which my reports have been concerned. I however view my recommendations for change as value added to both of those positions (I would not suggest any change in their assigned tasks), and have found in my visits to 11 nations over these past four months, that my perspective has been universally shared and supported virtually everywhere else that I have had the opportunity to interface with our country teams. I would sincerely hope that those involved in Australian-US interactions, which we (and State's S&T Advisor to the Secretary) have selected for what some would perceive as an experiment, would recognize that value-added is not just our intent, but indeed the most likely ROI.

Itinerary

21 October, Sunday: Arrive Brisbane~1430; Report preparation. RON Royal on the Brisbane

22 October, Monday: AM: Griffith University (all j.doe@mailbox.gu.edu.au); Vice-Chancellor Prof. Roy Webb; Deputy Vice-Chancellor (Research) Prof Dennis Lincoln (07 3875 5447); Prof Bill Hogarth, Env Sci (7431); Prof Geoff Dromey, Computing & IT (5040);Prof Robert Elson, Griffith Asia Pacific Council (5143); Prof Yew-Chaye Loo,

Eng (7 5552 8666); Prof Max Standage, Pro Vice-Chancellor (Health and Science)
PM: University of Queensland; Pro Vice Chancellor (Research) Prof David Siddle (d.siddle@research.uq.edu.au; 7 3365 9044); Deputy Vice-Chancellor (International & Dev't) Trevor Grigg(t.grigg@mailbox.uq.edu.au; 7366); Dir, Office of Research & PG Studies, Jan Massey (j.massey@research.uq.edu.au; 3640); Prof Melfyn Lloyd,Research Director, DSTC (melfyn@dstc.edu.au; 4311); Prof Simon Kaplan, Head, School of IT&EE; Prof Peter Lindsay, Software Verification Research Center; Dr Sue Golding, Earth Sciences; Prof Peter Brooks, Exec Dean, Faculty of Health Sciences; Dr David Kavanaugh, Dir of Research; Prof Joan Bryan, School of Population Health; Prof John MacKenzie, Microbiology & Parasitology

23 October, Tuesday: Queensland University of Technology; Pro-Vice Chancellor, Research & Advancement Prof David Gardiner (d.gardiner@qut.edu.au; 07 3864 2747); Director of PG Research Studies Prof Rod Wissler (r.wissler@qut.edu.au; 1303);Faculty of Science, School of Mathematical Science Profs Tony Pettitt (a.pettitt@qut.edu.au; 2309), Sean McElwain, Assoc Prof Vo Van Anh, Dr Erhan Kozan; Acting Dean & Director of Research, Faculty of IT, Prof Binh Pham (b.pham@fit.qut.edu.au; 1920); Director, Info Security Rsch Centre Prof Ed Dawson (e.dawson@qut.edu.au; 1919); Cooperative Information Systems Rsch Centre, Prof Arthur ter Hofstede; Info Sys Rsch Centre, Prof Guy Gable; Programming Languages & Systems Rsch Ctr, Prof Paul Roe; Smart Devices Rsch Group, Dr Jim Hogan
Evening: Fly to Townsville; arrive ~2100, RON Jupiter Hotel & Casino

24 October, Wednesday: James Cook University (first.last@jcu.edu.au; +61 [0]7 4781-xxxx): VC & Pres Bernard Moulden (4165); Pro-VC (Rsch) Prof Norman Palmer; Tropical Environment Studies and Geography, Prof Emma Gurris (ecology; 5476), Dr Scott Smithers (geomorphology; 4319); School of Marine Biology and Aquaculture: Head, Prof Michael Kingsford (4345), Prof Terry Hughes (recently elected toAus. Academy of Science; 4222); As. Profs C.G.Alexander (4282) & Garry Russ (4432); Prof Janet Greeley, Exec Dean, Faculty Arts, Ed'n & Social Sciences; Prof Jim Burnell, Biochem & MolBiol ; Seminar: Prof Bruce Litow, Info & Tech'y; Profs Mal Heron & Graham Sneddon, Maths & Physics; Prof Bob Henderson, Earth Sciences; As Prof Tom Hardy, Dr Nicole Kessissoglou, Engineering.

25 October, Thursday: AM: Australian Institute of Marine Science, Director Prof Stephen Hall (s.hall@aims.gov.au; 7 4753 4490); Resarch Director Dr Peter Doherty (p.doherty@aims.gov.au; 7 4753 4282); and staff
PM: (1) Museum of Tropical Queensland Director Dr Carden Wallace (carden@mtq.qld.gov.au; 7 4726 0600), and staff
(2) Great Barrier Reef Marine Park Authority, Chair Hon. Virginia Chadwick (v.chadwick@gbrmpa.gov.au; 7 4750 0847), Research & Monitoring Coordination Dr David Wachenfeld (d.wachenfeld@gbrmpa.gov.au, 7 4750 0896), and staff; Reef Hq Dinner: Prof & Mrs Stephen Hall, Dr Miriam Baltuck

26 October, Friday: CRC for the Great Barrier Reef World Heritage Area (CRCReef): CEO Russell Reichelt (russsell.reichelt@crcreef.com; 7 4729 8407)
Transit to Sydney via Brisbane; RON Keylodge Motel, Grafton NSW

27 October, Saturday: Report preparation; Transit to Sydney, RON Sheraton on the Park

28 October, Sunday: Transit to Auckland, NZ, arrive ~1530. RON Ascott Metropolis

Report 11: 28 October - 4 November 2001: New Zealand
A. New Zealand Observations
B. New Zealand Visits
C. Comments & Recommendations
Itinerary

A. New Zealand Observations

New Zealand is very green (physically and politically), and bumpy, a reminder of its tectonic and volcanic origins (with still active volcanoes and frequent earthquakes). Surrounded by a huge moat, NZ has few concerns about security; and with their deeply embedded anti-nuclear sentiments (in spite of their great pride in the Nobel Prize won by Ernest Lord Rutherford of Nelson) and Labor/left perspective on military involvement (the PM, I was told, cut her eye teeth during the anti-Vietnam peace movements of the 60s), NZ views its defence mission as support of UN peace operations. The economy is largely pastoral...the big change there has been major reversions from farm to forestry during the 90's, and a shift from sheep (hard on the land, lots of methane thus bad for the climate; the sheep population is down from 70M to around 45M...under 12 per person!) to dairy. What industry there is, is small...85 percent of NZ companies have under 5 employees, with no ability to absorb technology let alone perform R&D. During my visits many of my hosts bragged about a number of high-tech entrepreneurial companies...but it was the same very few at every stop. Per capita income is about on a par with Portugal (down from the top ranks of the OECD in the 50's); GDP growth for the last 12 months was 3%, but -- I was told -- everything went right so that's about the best they can expect with their limitations. NZ seems poised, some say, to become the world's B&B...pretty, comfortable, safe, and green.

Back in the mid-80's, NZ decided to shift from tight government control of the economy to a market driven, level playing field. It broke up and sold off many of the big state owned enterprises, eliminated subsidies, reduced government input to S&T, and converted its various government ministry labs to commercially operating (but still government owned) Crown Research Institutes. It was during this period, around 1986, that the US treaty relationship with NZ changed as a result of their non-nuclear legislation...we are now friends, not allies (although they still participate in, indeed rely heavily upon TTCP). It has only been in the last few years that government has again begun to recognize that with the world's 4th largest EEZ, international commitments for maritime surveillance and assistance in a huge area of the South Pacific, a somewhat less than benign 'moat' given piracy in the SLOCs they depend upon, illegal aliens, illegal and unreported fishing, an embarrassing standing in the world's rapidly globalizing economy, and little if any value-added to many of its commodity exports (e.g., much of the timber leaves to Japan as logs or chips), it does have a responsibility to create an environment conducive to economic growth[158]. At issue is Labor's seriousness, and their willingness to pay the costs -- social as well as economic -- of the security, modern conveniences, and commercial growth they clearly want.

[158]A few examples of some of the disincentives for investment and excellence that were mentioned to me: Corporate income tax rates are 36%, compounded by a 12.5% sales tax on virtually everything (the government even charges itself, even for overseas purchases; and all major acquisitions must be amortized at 10%/year for ten years; as a result of such policies, there's a lot of smoke and mirrors in the budget numbers). When the Labor government came to power in 1999 it raised personal income tazes on the rich, defined as anyone making over NZ $60K/year (~US$25K). There are also, I was told, tax penalties for R&D expenditures. In tertiary education, the Universities are funded on the basis of 'equivalent full time students'...irrespective of the nature or area of their studies; and any student over 21 can attend any University of their choosing, with no testing or grade requirements.

The two strategy and policy areas of particular interest to me were, of course, defence and S&T. These are addressed in some detail in my visit section. To summarize, in the first, the critical decisions coming up are in the maritime arena; NZ has already given up its air combat capability, and has committed to mechanizing their previously excellent light infantry. The major naval issues are whether they will upgrade the mission suite on their 6 P3s, how if at all they will replace their 3rd FF, due to be decommissioned in 2005, and how to address the mobility issues raised by their decisions to buy 105 light armored vehicles for the Army. I am told the acquisition costs for just these sorts of basics-- on the order of NZ $10B -- are very unlikely to be affordable. Nevertheless, the Labor government is now at least engaged in attempting to understand the nation's security situation and international commitments, and is talking with Defence about requirements.

In S&T, the words are starting to sound right. There is recognition that technological development is critical to economic growth, and a "Science and Innovation Advisory Council" has made some initial suggestions. Review of the tax structure and tertiary education are, I was told, underway. There is at least a verbal commitment to raise the S&T investment from the current 0.62% of GDP, to 0.8%, although the actual growth has been sporadic, and there are a multiplicity of targeted programs with overlapping and occasionally conflicting objectives, and more than a bit of robbing Peter to pay Paul. As in Australia, there is no tradition of treating S&T strategy and policy as topics of academic interest, so while there is no end of advice from many quarters, there is no sound broad basis of rigorous analysis on which to base policy changes, nor even serious questioning of some of the structural aspects of the system (e.g., the CRIs, alignment of educational support with costs and national needs). Generally however it is recognized that one of the most serious deficiencies is the grave imbalance between government and private investment in R&D, compounded by the inability of most NZ companies to uptake the results let alone perform their own research. The dairy industry is a bright spot, but as one of my hosts asked, how far can you go on milk?

All that said, there are of course some individual niches of excellence, and some areas of structural strength. NIWA, the marine environmental CRI for example, is thriving (though with almost all of the available 'market', thus threatened if the government decides to reduce investment in the marine environment), and its ships are the envy of their CSIRO and university neighbors to the west. The population in general is well educated, and the electronic infrastructure -- if not the road and rail system -- appears adequate. There is plenty of hydroelectric and geothermal energy, with opportunities for other renewable sources (e.g., the tidal head through the Cook Strait). The farming resources are superb, with significant potential for more value added through both product development and BT, if the country can get its policies and motivation right. The Universities are basically in good shape and enthusiastic about research, and could do a lot more given the opportunity. And while the national security environment -- defined in the somewhat broad sense used here in the US -- may not be quite as benign as some in NZ perceive it to be, they are indeed in a less than intensely contested corner of the world, and have a good number of English speaking friends who can help, should they be willing. Then again, there's always ecotourism, trees, wool, and milk...

B. New Zealand Visits. I visited only the North Island, but managed to hit a sufficiently diverse set of organizations -- government S&T policy makers and sponsors, Defense development office and lab, a Crown Research Institution (CRI, government owned lab), and two universities -- that I got a reasonably good feel for the current dynamics; the major gap was industry, which however at this point plays a very small role in innovation in the country. I also drove from Auckland

down the east coast to Wellington, and back up through the middle of the island, so I gained some appreciation for the basis of the commodity-oriented economy (sheep, dairy, trees), the importance of Maori culture (Government departments all have Maori mottoes), and the nature of the transportation infrastructure (third world). Instead of listing visits chronologically as in Australia, here I'll discuss first visits to federal S&T sponsors, then S&T 'providers', then the Defence organizations. Per usual for these reports, however, many of the opinions expressed by my hosts during my visits have been reflected in the Observations section.

MoRST: (Wellington) The Ministry of Research, Science and Technology is responsible for S&T policy issues, in particular for that element of NZ's 'innovation system' that is funded through "Vote:RS&T" (the budget is subdivided into various "Votes"; others of interest for S&T are Education, and Economic Development). The Foundation for RS&T, the Royal Society of New Zealand, and the Health Research Council are the 'purchasers' of research, and the 9 CRIs and 8 Universities are the primary providers (industry will be playing a larger role in the future)[159]. Additional innovation oriented programs are managed by Industry NZ.

In the early 1980s, the New Zealand government shifted from a policy of government ownership and extreme interventionism, to a 'hands off' market orientation. All subsidies were eliminated in a attempt to create a 'level playing field', and many government enterprises were privatized or, like the CRIs, forced to act as companies. Consistent with this approach, S&T funding fell from 0.8% of GDP to under 0.6%. Over the past several years however the attitudes have changed significantly as the Crown (including the current Labor government) has come to recognize that it does have a role in fostering economic growth (in the interim NZ had fallen dramatically, from the top tier into the lower half of OECD GDP/capita rankings). The goal since the mid-90's has been to return to 0.8%[160], as well as to stimulate industrial R&D investment (now less than a third of the total, ~NZ$350M or 0.3% of GDP) and to shift the mix of funding across the spectrum to stimulate both very basic and applied research. Results have been mixed however, and although the Labor government provided a $44M increase in 2000-01, it fell to a near-zero real increase of $11.6M for 01-02. The total $485.7M in Vote: RS&T is divided into 'goal' segments, with Economic Goal getting 43%, Knowledge 25%, Environmental 18%, Social 10%, and 'Shaping the System" (admin) 4%; for each of these goals, there are several specific programs or funds, targeted at a range of providers and objectives[161].

Two major new initiatives last year were the appointment of a Science and Innovation Advisory Council (SIAC), and the establishment of a $100M Venture Investment Fund (VIF).

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[159]The CRIs are: NZ Pastoral Agriculture Research Institute Ltd, NZ Institute for Crop & Food Research Ltd, Institute of Environmental Science and Research Ltd, Forestry Research, Horticulture & Food Research Institute of NZ Ltd, Industrial Research Ltd, Institute of Geological and Nuclear Sciences Ltd, Landcare Research Ltd, and National Institute of Water and Atmospheric Research Ltd, which I visited. The Universities are: Univ of Auckland, Univ of Canterbury, Lincoln Univ, Masey Univ, Univ of Otago, Victoria Univ of Wellington, Univ of Waikoto, and the new Auckland Univ of Technology. There are also 26 polytechnics, some of which do a bit of research, and 10 non-governmental industry linked Research Associations: fertilizer, wool, building, cement and concrete, dairy, heavy engineering, leather and shoe, logging, meat, and textile services.

[160]One of my hosts noted that this 0.8% goal is the same as Ireland's, which has a comparable population. He then facetiously commented that Ireland has had trouble meeting this goal because its GDP is growing so fast, whereas NZ has taken the opposite approach, increasing the percentage by reducing its GDP.

[161]E.g., the "Knowledge" goal ($122.7M) includes the basic research Marsden Fund ($27.8M) that is administered by the Royal Society, the New Economy Research Fund ($53.1M) for research and capacity building in areas of emerging enterprises, the Non-Specific Outcome Fund ($28M) for the CRIs, Promoting an Innovation Culture ($3M), and Supporting Promising Individuals ($10.7M). The RSNZ newsletter lists some 32 programmes for the total innovation investment of $826M; this includes Vote: Education funding for University Research, Health Research, and the new $100M Venture Investment Fund as well as the base Vote: RS&T Budget.

SIAC's report "New Zealanders - Innovators to the World - Turning Great Ideas into Great Ventures" notes that "we can't expect to live like a First World nation if we have an economy dominated by low value industries -- unless we trade more profitably", and provides an Innovation Report Card that finds much good in the system, but considerable disparity of educational levels among different social groups, and a very low rate of commercialization of innovation. It sets seven 'challenges' for Government: reward 'can-do', risk taking and success; educate for a knowledge economy; become a magnet nation for talent; generate wealth from ideas and knowledge; excel globally; network, collaborate, and cluster; and take an investment-driven approach to government.

Central to SIAC's recommendations is a focus on moving to more high-tech industry, plus adding value to basic commodities (e.g. timber, much of which is now exported as trees), and the development of critical mass in SMEs to give them the capacity to take up the output of research. There are however few specifics in the report, so that even if government does act on the challenges, it is impossible at this point to predict the form of all the resulting programmes. One such new initiative is the VIF, $100M[162] of government funds to be co-invested with NZ private sector and international investors by a private-sector fund manager, into a 'portfolio of businesses with a focus on the seed and start-up stages of development' (brochure). My host stated that the government will try not to pick winners, but...BT and agribusiness are likely candidates, as is the small but growing electronics cluster near Christchurch. Further, in recognition of the limitations of the local market and the need for international reach, the Minister recently visited the US, Israel, and Singapore, they are trying to strengthen relations with Australia, and they have a country coordinator located in Germany and will place one in Japan. My host has been assigned the responsibility for interactions with the US, and they understand the importance of developing better relationships with us in S&T.

FRST: The Foundation for Research Science and Technology is an 'independent crown entity', the largest of NZ's three research 'purchasing agents' (others are RSNZ which administers the basic research Marsden Fund, and the Health Research Council), and manages the majority of the Vote: RS&T programmes. In addition to administering assigned programmes -- which it prides itself on doing very efficiently, with only 1.3% of the fund -- FRST advises the Ministry on investment priorities and funding allocation. With a Board that is dominated by commercial entrepreneurs, and the current government thrust toward economic growth through S&T investment, FRST is quite focused on pragmatic results, with a heavy emphasis on research for industry and funding of consortia (in recognition that many NZ businesses are too small to be able to take advantage of new technology). Their criteria are benefits to NZ, as opposed to the previous emphasis on publications in international journals. The Foundation is in the midst of reorganization, and has just completed a new plan (which contains some NZ eyes only material so I didn't get a copy). One major shift is from responsively funding lots of small individual projects based on 'best ideas', to active investment in larger ($3-5M) programs, where groups or consortia need to form a legal entity to bid against tender calls.

Looked at in terms of its clients, the research providers, FRST supports industry (through, e.g., Technology NZ), research associations (e.g., the building association), the CRIs and Universities, and -- in a new but growing program -- research consortia. It also administers a significant number of fellowships and scholarships (responsibility for this is split among the various purchasing agents, plus MoRST itself), and the $4.5M Maori Knowledge and Development research program. I spent much of my visit discussing likely directions of strategic investment with my host. The Foundation, with Industry NZ, has a Portfolio Group that is in the process of advising government on niche areas for support. It is expected that these will include

[162]This money is outside the Vote, with $50M taken from the bank accounts of the CRIs (which they had earned operating as state owned companies) and $50M from other state owned enterprises. Not surprisingly the CRI's are not pleased at having to pay 'dividends' on top of taxes.

ICT and material science, as well as significant aspects of BT, which -- given the importance of the dairy, sheep and forestry industries -- is seen as an essential core strength, in spite of popular sentiment against genetic engineering (the papers were full of articles about the recent government decision, based on a Parliamentary Commission inquiry, to continue to support research and field trials but extend for two years the moratorium on release of GMOs; rather typical NZ schizophrenia re wanting and needing modern technology while at the same time shunning the costs[163]). Another candidate is the entertainment industry -- a NZ firm developed some very innovative software for the America's cup that is now widely used in sports broadcasting, and Lord of the Rings was recently filmed in NZ. Public good research, e.g. in environmental areas, will need to directly support policy, e.g. in 'moral political leadership' in topics like climate change, NZ's international obligations, regulations, pest control (they have a major problem with introduced predators), and stock dynamics for fisheries (they have a transferable quota system). Not surprisingly, one of the biggest challenges is what to 'kill off' to support the new priorities.

RSNZ: The Royal Society is New Zealand's version of a National Academy. Its three main roles are to be the 'guardian of excellence' (through the Fellows), to promote science (like our AAAS), and to fund or 'purchase' science, where they are responsible for the underpinning, 'blue sky' research through the Marsden Fund, plus some fellowship and scholarship programs. Our host was the Chief Executive, Dr Steve Thompson, who came to NZ from Canada four years ago, and until recently was at the Foundation. We spent much of our time discussing the characteristics of NZ's innovation system, and Dr Thompson's writings and comments strongly influenced my Observations. Some of his major points[164] include:
- Science policies are basically on track, with incentives to move research in the right direction (increases at the basic and applied ends of the spectrum, leveling the previous 'bump' in 'strategic' research); the structure of the S&T sector has yet to follow, but should as a consequence of system functions and goals.
- Closer alignment of the various budget Votes is needed, likewise fewer funds trying to do the same things (The RSNZ newsletter lists 32 programmes for the $826M total government innovation funding). Progress toward the stated objective of 0.8% of GDP is also ended.
- The largest single barrier to business innovation is the predominance of tiny firms (TMEs: 85% of NZ companies have only 2-5 employees) which neither understand research nor have the capacity to absorb its results. The private sector invests only $350M in R&D (mostly D), <0.3% of GDP (OECD average = 1.2%); only 700 of the 300K or so companies have any R&D capability, and they have almost no access to FRST funds (Technology NZ is at only $24M, and was cut this year; and Grants for Private Sector R&D is $10M, down $1.8M; however rules for Research for Industry [$170M] are changing to allow industry leadership and participation). There is a tax disincentive for industry to perform R&D (under review), as well as an extremely heavy (12.5%) and all-inclusive sales tax, plus high income taxes on the 'rich', defined as those who make >NZ$60K/year. Further a 1998 Foresight exercise raised expectations, but lack of implementation has alienated those who contributed most seriously.
-The Crown Research Institutes that get some 2/3 of government S&T investment ($350M of Public Good RS&T funding -- compared to $40M in Universities -- plus almost as much from other sources) are a mixed bag, challenged to both do research for the benefit of NZ, and make a profit (which was skimmed of $50M for the VIF). They have few links with Universities (with

[163]Or as the MoRST web site states it, "the decisions seek to preserve New Zealand's opportunities to benefit from scientific developments while protecting our unique environment".
[164]Summarized from our discussions and "Chasing the Rainbow: New Zealand Science and Technology", Dr. Steve Thompson, 31 Oct 01

whom they compete for S&T funds) and no role in education, and are seen by industry as competitors (at public expense).
- Universities are strapped for funds, and struggle to maintain their research base: they get about $144M (estimate) from Vote: Education, some $40M from FRST, $38M from HRC, and $54M from student fees. A new fund of $60M over four years from Vote: Education for Centres of Research Excellence should help, to a degree.

NIWA: The National Institute of Water and Atmosphere is the second largest (behind AgResearch) and probably the most successful of the nine Crown Research Institutes (CRIs), formed in 1992 when the government restructured its bureaucracy and turned the research labs of its various Government Departments into government owned 'limited liability companies'[165]. NIWA (and the other CRIs) now operates like a commercial concern, with full commercial powers (e.g., borrowing, forming JVs and subsidiary companies), and responsibility for funding virtually all of its operations, including the ships and supercomputer (Cray T3)[166]. By focusing on the quality of its science and at the same time providing valuable information to both government and industry, NIWA has been very successful at this, with a 2001 revenue of $77.1M (compared to $36.2M in 1994) ($37.4 from Public Good Science[167], $13.7 Ministry of Fisheries, and $26.0 Commercial income), a capital expenditure of $8.6M, and a net profit before tax of $7.3M ($4.7M after tax). They have 582 staff including 429 science and technical (plus 35 PostDocs and 83 MS and PhD students), and through the wholly-owned NIWA Vessel Management Limited operate some 39 research vessels, including the 2 major ships they acquired in 1995, the deep-ocean *R/V Tangaroa*, equipped with a Simrad EM300 multibeam swath sounder (which they contend far outperforms the Navy's hydrographic capabilities -- see NZDF section below), and the acoustically-quiet coastal *Kaharoa*, designed for a combination of fisheries and oceanographic research[168].

NIWA's research program covers five areas: atmosphere and climate, freshwater systems, marine and coastal, fisheries, and aquaculture and fisheries enhancement. My dynamic

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[165]It pooled the government scientists' salaries, put 80% into the 'public good' S&T fund for which they now compete with Universities, and told them to go to the private sector for the rest. I was told that one has failed, many are struggling, and even the Agriculture CRI has had to transform itself and change its core skills.

[166]Although the intent is for the CRIs to be competitive in research with Universities, marine science is capital resource intensive and expensive, so that -- I was told -- NIWA is really more collaborative than competitive with the academics. It does however dominate the field, getting about 85% of the market. Share size and limited growth potential have impelled them to seek opportunities outside NZ, and as discussed below they now have subsidiaries in the US and Australia. To quote NIWA's Chairman from their 2001 annual report, "the limited investment by the Crown in environmental science is increasing the Institute's reliance on further growth in consultancy revenue to maintain financial viability. Without matching growth in research funds, there is a risk of NIWA evolving toward a consultancy-dominated company which has reduced ability to provide high grade science for the benefit of New Zealand. To counter this, NIWA is pursuing opportunities to undertake high quality, interdisciplinary environmental research and consultancy with partners in the United States and Australia. At the same time we are working with the Crown to ensure that the recent change requiring dividend payment by CRIs does not jeopardize the need to reinvest in the public good environmental science undertaken by institutes such as NIWA for the benefit of New Zealand". This last refers to the $50M the government took from the CRI's accounts to initiate the Venture Investment Fund, see the paragraph on MoRST.

[167]While most of this comes from competitive projects managed by FRST, CRIs do receive an allocation of Non-Specific Output Funding equivalent to 10% of the value of public good science contracts awarded in the previous year.

[168] *Tangaroa* was designed for Antarctic work, and in addition to its work for NZ is rented by the Japanese. Their pricing is based on 280 day/year operation (at $35K/day), but last year they worked 328 days.

and enthusiastic host, Deputy Chief Executive (Strategic Development) Dr Rick Pridmore, noted that their strength is in the quality of their science and sticking to their core business. They recruit internationally (with competitive salaries - another advantage of being a company) as well as bring in many visitors to fill gaps in their skill base. They operate on the principle of 'one NIWA'; there are no internal Divisions, and all their work, across all 15 locations, is managed on a project basis, with the project managers able to select their own teams and develop synergy for multidisciplinary research. To increase public dissemination of one of their important products, climate information, in early 1999 they formed the National Climate Centre. This centre publishes summaries and 3-month climate outlooks, give talks around the country, and provides advisory services; its revenue has grown from $40K initially, to over $1.5M last year[169]. They plan to establish a similar National Center for Water Quantity and Quality in 01-02, which will "offer flood forecasts and provide advice on the impacts of land use and climate change on the nation's freshwater resources". These organizations provide a means of testing their hypotheses and models, while simultaneously performing a public service and whetting the appetite of regional authorities and companies for more detailed advice, for which of course they charge a consultation fee. NIWA also operates an Institute of Aquatic and Atmospheric Sciences together with the University of Auckland, in order to attract and participate in the teaching of postgraduate students. Further, recognizing the limited market and resources in NZ, they have -- using contacts established through their research collaborations with US partners -- established the non-profit NIWA Environmental Research Institute on the campus of the University of Connecticut, and the for-profit NIWA USA Inc in Ann Arbor, Michigan, which is linked with MFG and Limnotech to offer environmental consultancy. NIWA-ERI has been very successful in developing partnerships between NIWA and scientists from many US research institutes and universities. It provides an additional outlet for their talent, access to US funding such as NSF and NOPP, and a recruiting tool. They have a similar organization, NIWA Australia Pty Ltd, headquartered in Brisbane.

UOA: Auckland bills itself as the "First City of the Pacific -- Taonenui Tuatahi o te Moana-nui-a-Kiwa", the largest (and growing and multiethnic) city in NZ. Its University of Auckland, established in 1883, also is NZ's largest, with 28K students (5600 postgraduate; 1600 international and growing rapidly) and three campuses, the principal one being in the middle of the city (the others are the medical school in Grafton, and an industrial theme park). UOA has 1600 academic staff in seven faculties[170] each with several departments and many 'research clusters', and a number of cross-faculty Centres, and is in the process of preparing to compete for the new Centres of Research Excellence. The University 2001 budget is NZ$402M, comprising government subsidies ($170M), student tuition fees ($86M), International student fees ($15M), external research income ($83) and 'other service' income ($48M). UOA prides itself on having won almost 28% of the Marsden Fund basic research awards between 1995 and 2000, and 35% last year, receiving $9.7M, almost twice the amount of the next university competitor[171]; they

[169]They also publish a quarterly biodiversity update and a periodic resource management newsletter entitled *aniwaniwa*, which is Maori for rainbow (their motto is Taihoro Nukurangi, Where the water meets the sky)

[170]Architecture, Property Planning and Fine Arts; Arts; Business and Economics; Engineering; Law; Medical and Health Sciences; and Science

[171]The univ ranking was: U OA ($9,8M, 29 grants), Otago ($4.9M, 12), Canterbury ($2.4M, 7), Massey ($1.9M, 4), Waikato ($.5M, 5), VUW ($1.4M, 6), Lincoln ($1.5M, 1) and the new AUT (0); for others: Malaghan Inst Med ($1.0M, 2), IGNS ($.9M, 2), IRL ($.8M, 2), AgResearch ($.8M, 2), NIWA ($.75M, 2), Hort Rsch (($.7M, 20), Children's Issues Ctr ($.6M, 1), Crop & Food Rsch ($.45M, 1), NR Math RI ($.626, 1) and Landcare Rsch ($.2, 1)

also fund some $2M of basic research with their own funds. Overall, they rank fourth among the 8 Universities in total Public Good science funding.

Commercial research income now almost equals that from the government, and is increasing. Their commercial research contracts are managed, and their IP owned and commercialized, by their wholly owned company, Auckland Uniservices Ltd; of this company's almost $37M revenue ($33.4m from research and consulting, $3.5m from IP) in 2000, 20% was from NZ businesses, 41% from central and local government, and 40% from overseas (32% pharmaceuticals and biotech, 6% engineering, 1% other). They have a total of some 1400 projects, of which 546 (from 259 clients) are valued at over $5K; they note with some pride that in 2001 UOA "will undertake more commercial research than all but 28 US universities" The University has spun off 8 companies, and expects considerably more revenue from its IP in the future. The commercialized research areas include bioengineering, neuronal rescue, structural biology, inductive power transfer, surface science, materials chemistry, and sail aerodynamics.

My visit comprised introductory discussions with Deputy VC (Research) Tom Barnes, then a briefing by myself on ONR programs, short presentations by several faculty members, and a tour of the test chambers of the Acoustic Research Centre (heavily used for testing characteristics of building materials) and some of the materials engineering and surface science labs. In underwater acoustics, Prof Gary Bold participated in ATOC, and Dr Chris Tindle of the Physics Department (who spent a sabbatical year with Dave Bradley at ARL PSU) has been working under an ONR funded subcontract via MPL, UCSD on acoustic propagation in the surf zone, using his new and very fast technique called Wavefront Modeling (manuscript submitted to JASA). Prof John Montgomery is a sensory biologist who runs UOA's marine program (some 12-15 staff). His research in biomimetics includes electrosensory hydrodynamic trailing (out to about 10 min time late) and active boundary layer control by fish, and what he terms the 'acoustic landscape', use of acoustic noise in navigation which appears to be a component of the process by which larval fish home in on reefs.

The Research Centre for Surface and Material Science has developed new anodes for aluminum smelting and high voltage magnesium anodizing, and is working on polymer gel electrolytes and lithium ion battery cathode materials. Prof Wei's 'cluster' of surface science engineering has about 15-20 staff and 30 students and is researching nanocrystal coatings deposited in very low partial pressures to improve high temperature corrosion and wear. Prof Bhattacharyya is Director of the Centre for Composites Research (which I visited) which will bid to become one of the new Centres of Research Excellence. The Centre has 23 associated staff, and a wide range of testing and analytical facilities. They have many collaborators both in NZ and overseas, including Australia's CRC-ACS (see Report 9), and Cornell, U Md, and CRREL plus several companies in the US. Projects include studies of soft impact damage to laminates, a patented technology for fast composite manufacturing, roll forming of thermoplastic sheets, and wood fibre and polymer composites.

VUW: Wellington likes to call itself NZ's 'smartest' city. In addition to being the Capital, it has the highest average incomes, is 'fully wired' with >4700 internet-connected computers per 100K population, and boasts that 30% of its adult population have University degrees. The Victoria University of Wellington (Te Whare Wanagao o te Upoko o te Ika a Maui), now 100 years old, is the nation's 4th largest with about 14400 students (43% part time; about 20% postgraduate, 10% international) and 690 academic staff. They have three campuses; the Kelburn campus which I visited has science, arts, and commerce; the downtown campus has law, and one on Vivian Street architecture and design. There are four faculties: Humanities and Social Sciences (the largest), Commerce and Administration, Law, and Science (with schools of Biological Sciences, Chemical and Physical Sciences, Earth Sciences, Mathematical and Computing Sciences, Psychology and Architecture). Research accounts for some 20% of VUW's budget, and its external contract

research has more than trebled in the last 5 years. There are some 32 research institutes and centres. VUW has its own company, Victoria Link Ltd, as its interface with business and government sectors, and typically has over 50 projects at any time. It also has a VUW Foundation for fund raising, which provides about a $M in research support.

ProVC Prof Englert listed their science strengths as ecology and biodiversity, geophysics, materials science (in which, with two of the CRIs, they will bid for Centre of Research Excellence), pure math, and the study of aging. VUW's anniversary brochure also highlights geological and climate research in Antarctica, high temperature superconductors being developed jointly with the CRI Industrial Research Ltd, and studies of the energy required to produce different types of common building materials. They are particularly proud of having recently attracted Prof Paul Callaghan, a Fellow of the Royal Society of London, to their new Alan MacDiarmid Chair[172] in Physical sciences. Prof Callaghan, whose lab I visited, uses nuclear magnetic resonance to study the rheology of complex fluids, and flows through porous media; his work should be of significant interest to the materials program at ONR and I will pass on copies of his papers.

As at UOA, after the introduction by the ProVC, I described ONR programs, and then was briefed by a number of academic staff, on programs in ocean science, earth science, math and IT, and psychology. Prof Bob Galudie, who was previously at the University of Hawaii, discussed their biological oceanography work, which focuses on the issue of recruitment. For the last couple years they have worked to build a collaborative program with US and South Americal scientists (HUSAC) to study biodiversity and linkages from NZ through the Southern Ocean with the Humboldt Current. They have a proposal to Sloan Foundation regarding a web based data management process. With the Fisheries Commission, they expect to compete with NIWA and UOA for a Center of Excellence in marine science. Also, they believe the deep ocean is a key area for their fisheries, and to this end are signing an MOU with UH to allow easier movement of faculty and students, and are looking to fund a five year program to dual home-port UH's new SWATH oceanographic research ship in Wellington, for use of their deep submergence systems.

Materials research, in addition to the NMR of soft materials and porous materials work of Prof Callaghan and the high temperature superconductor work with IRL (in association with American Superconductor Corporation and with USAF funding), includes nanophase calcium silicates for developing materials with specified bulk properties, colossal magnetoresistive materials in data storage, electroceramics and mixed metal-ceramics, and high technology glasses which are competitive with crystalline materials for many purposes. Interestingly, their research philosophy in many ways parallels ONR's 'Grand Challenge' approach, of "Materials by Design". To quote from some of their writings, "the creation or improvement of modern wealth-creating industrial products is predicated on the ongoing development of new materials with novel functionality...the design of specific functionality requires both a physical understanding and the ability to calculate and model interactions and performance". Other research groups in chemistry and physics are working on sensor arrays for detecting chemical compounds, wide bandgap semiconductors, focused laser and particle beams, and high energy hydrocarbons.

The School of Math and Computing Sciences is one of the strongest in the faculty with 36 academics, and claims to be one of the top 10 in the world in theoretical computer science. Among their other areas of expertise are the geometry of high-dimensional structures and applications to data bases, statistics and ops research including an interesting approach they called 'fishing tomography' to estimate stock sizes from analysis of commercial catches, and warranty analysis. The School of Earth Science notes that NZ's tectonic activity plus friendly human environment make it an extremely attractive place to study. Their expertise spans geology, solid

[172]Prof MacDiarmid, a New Zealander and a Victoria Graduate, now at the University of Pennsylvania, was a last year winner of a Nobel Prize (only the 3rd New Zealander so honored) for his work on conducting polymers.

earth geophysics, meteorology (they train many of the NZ Met service forecasters), and both physical and human geography. They are developing a proposal for a University Centre for Earth Environments, Change, and Impacts, with the intent of developing improved risk analysis tools for both high impact natural events like earthquakes, and commercial activities such as the tourist business (e.g., introduced organisms) and the switch from sheep to dairy farming in Southland.

Prof Susan Schenk, a newly arrived (from Texas A&M) behavioral psychologist, briefed on her new program (in conjunction with neurologists and biologists) on the effects of drugs on brain and behavior, focusing on Ecstasy which is one of the largest drug problems in terms both of escalation of use and demonstrated long term impact of cerebral blood flow and learning deficits. Overall the Psychology School is very strong, with 23 staff and 125 honors, MS and PhD students. Among their areas of expertise are cross cultural psychology (we talked about the importance of this field to peacekeeping, disaster management, and similar multinational military operations), forensic psychology, aging, and occupational stress. We jokingly commented at the end of our discussion that after four months on the road and innumerable briefings, this very last one might well stick in my mind. Indeed it has, and I would suggest that if and when Yvonne Masakowski (or some other IFO rep) makes the 'psychology tour' of Australia, as I have repeatedly recommended, she include a stop in Wellington to check out more thoroughly this School's capabilities.

NZDF: NZ has not experienced any serious military threat since 1942, and generally both government and population believe that they exist in an extremely benign security environment. Nonetheless, until November 99, the government favored a balanced Defence Force, remaining firmly engaged in the world and making its contributions both as a good global citizen, and to support its regional commitments (NZ is responsible under international agreements for a very large maritime area in the Pacific). Force structure plans therefore included updating the air combat capability with F16s and replacing Navy's 3rd FF with a new combatant when it goes out of service in 2005, as well as equipping the Army -- traditionally an light infantry organization (3 Battalions, one ready, one less ready but staffed with regular forces, and one reserve) -- with 105 new light armored vehicles. The Labor government which came to power at that time, however, has a significantly different ideological bent that includes a strong element of pacifism and a long standing distrust of the military. The PM herself, for example, was active in anti-Vietnam activities in the 60s and 70s, and members of Labor party tend to ascribe their nation's participation in that conflict to the desire of the military, as opposed to a decision of the government. Among their decisions has been to eliminate their air strike capability and sell the existing force, and not to replace the FF in 2005; nor is ASW considered a mission for their 6 P3s. Thus Army was to be the primary force, with a principal mission of contributing to UN peacekeeping operations. NZDF has been further impacted by severely restricted budgets (now about 1.1% of GDP, ~ US $600M), exacerbated by the tenor and length of their operations in East Timor (they are coming up on their fifth troop rotation).

Attitudes have however changed to a degree over the past several months. Australia's experience with illegal immigrants led to a recognition that the local maritime environment is not completely benign, and September 11th and ensuing threats by the Taliban and anthrax hoaxes in Australia, plus their own commitments of special forces to combat terrorism, as well as transport and humanitarian assistance -- plus increasing concerns with illegal fishing, piracy, drug activity, and movements of nuclear and other waste through NZ's huge EEZ (4th largest) and the maritime areas for which the country has accepted responsibility -- all are leading to greater willingness to seek advice about security from the Defence Force, and to recognize that NZ does indeed have to deal with the world outside and pay some attention to the concerns of other nations. Further, there will be an election prior to next November, and Labor would like very much for defence not to be an issue of debate. Thus the next few months, in which significant decisions must be made,

will be a watershed. CDF and the Secretary are being asked to provide information on the scale of projects and costs needed to meet NZ's international commitments, and the government must determine what is in and out of the available funding envelope, and the associated impacts.

Some prior decisions are likely to prove irreversible. At this point, for example, many of their pilots and aviation ground support personnel have already gone overseas, so the air combat capability is probably lost. Motorization of their previously excellent light infantry has impacted that niche expertise, and simultaneously created a mobility problem. Perhaps the major issue therefore is their maritime capability, and their neighbor and real guarantor of NZ security, Australia, appears not prepared to quietly accept a downgrading in that area[173]. NZDF has recently re-winged their P3s (5 lights and a heavy), and they badly need to upgrade the cockpit and redo the complete mission system (some have the original 60's equipment, others systems dating from the early 80s) for maritime surveillance. They have taken a 'very holistic' look at maritime surveillance and identified only three areas (underwater, number of communications channels, and wider ESM spectrum) where Defence needs exceed those of civil agencies. The government seems to recognize the importance of these aircraft for long range maritime patrol. The government would rather not have another 'pointy ended' ship to replace the expiring FF, but recognizes the need for a transport for the light armored vehicles, and also would like to have ocean going patrol boats equipped with helos or coverage of their extensive maritime areas. Given that the average sea state around the northern island is 4, that around the southern island is 5, and its typically SS6-7 further south -- the average is also ~SS4 in the areas around the island nations -- small ships and very light helos like Australia uses for its Coast Watch system are unlikely to be suitable. Government is also looking at whether or not it needs to retain a hydrographic capability, and if so whether that should stay with Navy (or be assigned to NIWA). NZ used to provide hydrographic services as part of its military assistance to the Pacific island nations (which badly need to update and digitize their charts), but under current practice Navy can not do so unless they are paid, which those nations can't afford.

With respect to R&D, within the last three years they have centralized control and funding over the Defence Technology Agency (it used to be Navy's, with some AF participation). Each service retains its own development cell and most development work is done to their requirements, with Defence coordinating as necessary and sponsoring longer range core projects. CDF is very committed to S&T, recognizing that they need to pay even more attention to science as the force shrinks; and they make extensive use of TTCP as a window to developments in the other nations. The bottom line is that at least the NZDF, after a rather 'dark period', is again able to help the government formulate its security plans and goals, and to argue for a Defence role in national aspirations to 'close the gap' technologically with the outside world through indigenous capabilities, and for an acquisition approach that considers whole-life costs instead of just purchase price. It remains to be seen what the nation thinks it can afford.

DTA: The Defence Technology Agency is located at the back side of the naval base at Devonport, just across the bay from Auckland. The location bespeaks its history, starting as a naval sound lab in the 1950's, then becoming tri-service (though still fundamentally naval oriented) as the NZ Defence Research Lab in the 1960's. As part of the nation's move away from government ownership and S&T sponsorship over the last couple decades, its name and mission were changed in the early-90's (at the time of creation of the CRIs), to the Defence Operational

[173]Australia's significant *Defence 2000: Our Future Defence Force* White Paper, notes both the strong similarities and "sometime surprising differences between us...New Zealand's strategic perrceptions and outlook differ from Australia's in significant ways. New Zealand's view that its strategic circumstances may not rewquire the maintenance of capable air and naval forces differs from Australia's view of our own needs. We would regret any decision not to maintain at least some capable air and naval combat capabilities", p42. One might imagine that personal communications between Defence personnel may have been slightly more pointed than even this quite strong public statement.

Technology Support Establishment. This reflected Treasury's edict that individual departments could keep their R&D organizations only to perform operational support for the department, not research; commensurate with that change, funding was decentralized to the individual services, their projects became short-term and operationally oriented, and they again became primarily a Navy support organization. About 3 years ago funding was recentralized to Defence (indeed they are not now allowed to accept funds from individual services, or from outside Defence); more recently the name was again changed to DTA to reflect the recognized need for R&D; and under the direction of the Assistant Chief of Staff for Development, they are reverting to long range planning and more of a technological focus.

The lab's size and focus has also changed considerably over the years. From a peak of over a hundred staff, they now have 55, with a budget of NZ $4.7M/year (including salaries; they are however provided ship and air time at no cost by the operational forces, and use this as part of their contribution to TTCP). Projects are nominated by the services and headquarters, and selected by the Defence Technology Committee. Reflecting their history, they are still do about 55% of their work for Navy, 35% for Air Force and 10% for Army, albeit the Army component is growing. One of their historical strengths was acoustics; they now are down to a single acoustician. In addition to their Maritime and Materials and Structures Divisions (which with 9 staff can deal with only the highest priorities, basically accident investigations and life extension, where they have done some very nice work), there is now an EW group (about 17 staff) that is concerned principally with advanced ESM, EO-IR sensors, C4I and net centric concepts, and operations analysis. With a budget that has been near static for a decade, their significant changes in orientation over the same period, and administrative constraints, they find their TTCP interactions crucially important, and need to look outside the country for a defence oriented S&T community to whom they can relate. One concern they expressed is that in some areas such as MCM, there is a growing disparity with the US in the level of technology.

C. Comments & Recommendations

We already have quite good coverage of NZ's Defence related research through their participation in TTCP; the IFO need not make further contact except as tasked for specific issues. However one concern that DTA expressed and that I share is the increasing technological (and affordability) gap between the US and our other friends (like NZ) and allies (like the other TTCP members). There's no easy answer to this problem, except to argue -- as I have in some of my earlier reports -- that there should be room in DOD's S&T programs for development of items specifically designed to improve the ability of other nations' defence forces to effectively and safely operate with us. This runs counter to the prevailing philosophy of focusing almost exclusively on US technological superiority; but if multilateralism, and particularly interoperability in military missions such as peace operations, humanitarian assistance, CT/CD/AP, etc., are to continue to be major components of CINCs engagement strategies (and after 11 Sept this seems pretty well assured), then we would do well to recognize that there can be major payoffs in directly helping friendly nations improve their ability to work in conjunction with US forces. A minor investment in technology can reap huge dividends on the front.

Both the NZ research organizations I visited, and others that I did not, contain -- not surprisingly -- pockets of expertise that should be of significant interest to ONR. Some of these relate to the nation's unique environment and geographic location, others to the abilities of exceptional researchers. Per usual, I'd suggest the IFO read through my visits section, and follow up as they believe appropriate. I will in particular pass on Prof Callaghan's NMR papers to Bob Pohanka, and if VUW is successful in its bid for one of the new Centers of Research Excellence, it would be well worth a follow up visit in a couple of years, particularly if they continue to pursue their

Materials by Design philosophy. So, I'd guess, will be all the winners of this new competitive programme. Once these new Centres are up and running, we (Dr Baltuck or another appropriate IFO rep) should visit them all. And, as noted in the Visits section, if Dr Masakowski does visit Australia, a side trip to NZ might well be in order.

Perhaps my major suggestion, which is not new to those who have been getting my emails, is that NZ should be included in Dr Baltuck's area of responsibility (indeed it may already be, although I didn't see this in the MOU with NASA). Our Embassy in Wellington is very small (and the Consulate in Auckland is one person), and while enthusiastic and interested in the issues, the 3-person Political and Economic staff would benefit greatly from guidance re S&T issues of importance, and from Dr Baltuck's assistance in identifying key organizations and individuals. Given Australia's strategic closeness to New Zealand, and NZ's responsibility for very large maritime areas in the Pacific, a modicum of attention to S&T on both North and South Islands should be considered an important component of her tasking to support our national agenda, and our Ambassadors and country teams in the region. In this light, I found Dr Steve Thompson to be a particularly astute observer, so that reading his RSNZ newsletters and periodically interfacing personally with him (he is very conveniently located almost next door to our Embassy in Wellington) would appear to be a first order of business.

From the standpoint of logistics, I would suggest that visitors (unless like myself they are geographers who feel compelled to get a feel for the land) fly not drive between sites; driving in NZ is quite stressful, not to mention dangerous-- another apt comparison to Ireland. I can also particularly recommend the Ascott Metropolis in Auckland for any visitors to that city. After 4 months on the road Cynthia and I developed a bit of expertise in judging accommodations, and it was the best value for money of all 11 countries. Enough advertising...the IFO has always tried to delete the 'travelogue' element from its newsletters, but after what my wife and I have been through I figured a couple words at the very end wouldn't be too amiss, perhaps even forgiven.

Finally I would like as a closing note to particularly commend the NZ Embassy staff for setting up an excellent agenda for me under the trying circumstance of the unanticipated and premature departure of the Defense attaché because of melanoma. I was able to cover a lot of territory in a short time, and sincerely appreciate their efforts.

Itinerary

28 October, Sunday: Arrive ~1530; RON Ascott Metropolis Auckland (Best hotel whole trip!)
Local Host: Consul Andrew Young (YoungAR@state.gov; 64-9-309 0274)

29 October, Monday: AM: Defense Technology Agency (f.last@dta.mil.nz; +64-9 445-xxxx); S.A. (Tony) Brown, Group Manager EW Group (5871); Ralph Marrett , GM Maritime Systems (5875); Patrick Connor, GM Materials & Structures
PM: The University of Auckland; Deputy VC (Research) Tom Barnes (t.barnes@auckland.edu.au; 64-9-373-7599x5872); Assoc Dep VC (Rsch) Prof James Metson (j.metson@auckland.ac.nz; 373 7599x2983); Assoc Prof Chris Tindle, Dept Physics (acoustics; x8871); Prof Gary Bold, Physics/acoustics; Prof Debes Bhattacharyya Head Ctr for Composites Rsch; Assoc Prof Wei Gao, Dept Chem & Materials Eng (x8175); Prof John Montgomery School of Biological Science (fish biology/neuroscience; x7208)

30 October, Tuesday: Report preparation; transit to Wellington, RON Vista Motor Lodge,Wairoa

31 October, Wednesday: Arrive Wellington @ 1500; RON James Cook Hotel Grand Chancellor

1 November, Thursday: AM: HQ NZ Defence Force, Brigadier Ian Marshall, Asst Chief Development (ian.marshall@nzdf.mil.nz; +64 4 496 0960)
PM: (1) National Institute of Water and Atmosphere (NIWA), Deputy Ch Exec Rick Pridmore (r.pridmore@niwa.cri.nz)
(2): US Embassy, Wellington: Counselor James Pierce (Political and Ec Affairs; PierceJA@state.gov; 64 4 462 6063); Political Officer Glenn Fedzer (FedzerGE2@state.gov; 64 4 462 6043)2 November, Friday:
AM (1) The Royal Society of New Zealand, CEO Dr Steve Thompson (thompson.s@rsnz.govt.nz; +64 4 472 7421)
(2) Foundation for Research Science and technology, Gp Mrg (Policy, Strategy & Evaluation) Nick Allison (nick.allison@frst.govt.nz; +64 4 917 7831)
(3) Ministry of Research Science and Technology, Sr Advisor John Arathimos (john.arathimos@morst.govt.nz; +64 4 917 2900/2862)
PM: Victoria Univ of Wellington (first.last@vuw.edu.nz; +64 4 463 xxxx), ProVice Chancellor (Research) Prof Peter Englert (5069); presentations by Dr Bob Gauldie, Ocean Sciences; Chemical and Physical Sciences, and Material Sciences, Prof Jim Johnston, Head of School (5334) & Alan McDiarmid Chair Prof Paul Callaghan, and staff; Earth Sciences, Prof Euan Smith; Math & IT, Prof Peter Donelan and staff; Psychology, Prof Susan Schenck & Head of School Prof Colleen Ward. Industrial Research Limited, Dr Jeff Tallon (Hi-T superconductivity; j.tallon@irl.cri.nz; +64 4 569 0117)
3 November, Saturday: Transit to Auckland; RON Riverside Motor Lodge, Cambridge
4 November, Sunday: Transit via Auckland & Los Angeles to Home; Dep ~1800, arrive ~2000

Report 12: Notes on Australia's 'Innovation System'
28 November 2001
Introduction
Strategy and Policy
Sponsors and Mechanisms
Performers
Comments
Acronyms

Introduction

As mentioned in Reports 8-10, having spent some 6 weeks in Australia talking to dozens of S&T policy makers, sponsors, managers, and performers, I want to set down some of the information I gained from them (and from the literature) about how the country's 'innovation system' seems to work. My principal intent is to provide ONR's future reps in Australia with the sort of guidance I would have liked to have, had I been fortunate enough to be stationed there. I have consolidated here much of what I heard from my many hosts, but in addition have expressed my own opinions about what I learned, and such opinions are solely my personal views. I would welcome either corrections of factual errors, or comments, pro or con, about any of my opinions and suggestions.

While there are a large number of players in the Australian S&T scene, after outlining the basic applicable policies I will focus here on just a few of the major 'sponsors' (e.g., DETYA, DISR and DOD), and general classes of S&T performers (Universities, CRCs, CSIRO divisions, other government R&D groups like DSTO and BMRC, and industry), rather than individual organizations[174]. Let me start with some caveats:

- I am assuming readers of this will have read my other Australian reports.

- Although PM John Howard's coalition government was recently reelected, the Ministers are likely to change; and in Australia's Westminster-based system (which operates at both federal and state level), the makeup of a Minister's portfolio can change from administration to administration. That is, the bureaucratic cards -- while themselves still (theoretically at least) basically the same -- can be shuffled (e.g., the Department of Industry, Science and Resources, DISR, could become DIR, with S somewhere else...or DSR with I on its own, etc[175]). Major policies and spending commitments, however (like those in the Defence White Paper, or the doubling of ARC's funding, or the new Centers of Excellence in ICT and BT) can be expected to remain in place. There are of course campaign promises to be kept and political debts to be paid, which may influence what and who go where, when, and how.

- In Australia as elsewhere, the post-9-11 world is different. The impact on S&T may ultimately be seen in structure, priority, areas of emphasis, or attitudes toward mobility. I make no predictions about this.

- There have been some recent changes in S&T organizations -- e.g. the ARC Act of 2001 which gives that important organization more independence and power -- and people -- e.g.

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[174] I have included a list of acronyms at the end of this paper, and also listed many of the web sites I used to get copies of papers or check my information about organizations.

[175] While I was writing this, it happened...on 26 November the PM reshuffled the Ministries;among other changes, DISR became the Department of Industry, Tourism and Resources; and Science -- along with CSIRO -- moved to the Education portfolio. This shift, breaking the close link between industry and science, may have interesting implications for the policies described in this paper, many which have emphasized commercialization over basic research. More below.

Geoff Garrett at the head of CSIRO -- which may soon change the scene considerably. As far as I was able to sample (and in my own opinion), such recent changes have all been for the better.

- I am writing principally for an American audience, and although there are many similarities between our countries and systems, there are also very substantive differences (e.g., federal vs state responsibilities, in say education or emergency management), only some of which I will mention, and many of which I probably didn't even notice in spite of their importance. I will in some cases make comparisons between our approaches, particularly when I believe that one or the other of us has a better practice that the other could consider.

Finally, it is good to recall a **few basic facts**, e.g. that Australia's six States[176] (I visited them all) federated to form the Commonwealth of Australia in 1901; and in addition to the six states there are two Territories, Northern Territory (which I did not visit) and the Australian Capital Territory (ACT) which contains the Capital city Canberra. The continent's size is ~7.7 million square kilometers, roughly the same as the contiguous 48 states of the US, yet the population is slightly under 20M[177], most of whom live in or near the few large cities (one or two in each state) or along the east coast, say from just below Sydney to near Brisbane. Australia's heritage and tastes are predominantly western (there is some diversity but it is localized except on campuses; and in the cities where I was, aboriginals are very scarce) and the standard of living is high, but of course Australia is at the other end of the world from its counterpart English-speaking intellectual centers in North America and Europe (and the exchange rates are not favorable).

For S&T these facts express themselves through State-Federal tensions and State rivalries (to a degree like in the US but of course their states are fewer but bigger), low internal mobility (e.g., most students attend University in their own State), a quite significant 'brain drain' to the US and Europe for a combination of better salaries and closer interaction with peers, a very small market thus a weak manufacturing base and the associated challenges of commercialization for offshore sales, and a degree of dependence on decisions of their allies, in particular the US (e.g., their major weapon system platforms are all foreign).

Further, due to some combination of sociology, the English style of education, and bankruptcy law (with no doubt a number of other factors), Australians are more risk-averse than US entrepreneurs; and for perhaps some of the same reasons, the government (especially DOD) is reluctant to 'buy Australian' unless the product has first been bought and used overseas, again preferably in the US. These factors actually give us at ONR a bit of leverage when it comes to influencing directions of development, as well as some very good value for money.

Strategy and Policy

There are four areas of policy that are of principal interest for my purposes, and a corresponding White Paper or policy document for each. The first, and most recent, is the PM's policy on Innovation, *Backing Australia's Ability: An Innovation Action Plan for the Future (BAA)*, released early 2001. *BAA* provides very specific funding guidelines for the major programs which will support Australia's R&D and commercialization thrusts for the coming 5 years. The second, which contributes heavily to the content and thrust of *BAA*, is the Minister of Education, Training and Youth Affair's *Knowledge and Innovation: a policy statement on research and research training (K&I)*, of December 1999. *K&I* set the stage for the ARC Act of 2001 which gave that key organization its independence, and defined the funding and management schemes

[176]Tasmania, Western Australia, South Australia, Victoria, Queensland, and New South Wales

[177]To put this in perspective, that's somewhat less than greater Seoul, Korea; or Malaysia

for university research and postgraduate research training[178]. The other two policies are sectoral: *Defence 2000: Our Future Defence Force,* "the most specific long-range defence funding commitment given by any Australian government in over 25 years" (to quote the Minister's introduction), and *Australia's Ocean Policy*, released in December 1998. It is worth noting that policies such as these are developed through a process similar to that used in the UK, basically through the issuance of a Public Discussion paper, followed by a public Consultation Process, and then the formulation and publication of the final White Paper, or policy statement[179].

BAA*:** The subtitle of the Government's Innovation Report for 01-02, -- *Backing Australia's Ability*, ***Real Results, Real Jobs **--** pretty well sums up the impetus behind Australia's current strong interest in S&T. The PM's foreword notes, "Australia is a nation with a proud tradition of innovation and science. We have always been a resourceful people and, through our ingenuity and creativity, we have excelled in many fields of endeavor. Now, our challenge is to build on this strong base, using innovation to turn local ideas and invention into incomes and jobs for Australians." The clear implication is that in the past, Australia has failed to "turn S&T into money" in the same way as have Japan, Korea, the US and Europe.

The basic innovation strategy, therefore, is output oriented. It is also strongly biased to the new 'high tech' fields, and very heavily weighted toward technology push, using a variety of funding and incentive mechanisms, and the full (and very large) panoply of Commonwealth-funded institutions -- CSIRO labs, CRCs, universities -- to try rush to market what now exists and thus develop corporate expertise and toeholds, and to prepare for the expected coming 'revolution' in new products from the '21st century' technologies such as IT and BT. Many of my contacts stressed that Australia really missed the boat last time around, in motor cars, computers, mobile phones, TVs, and other consumer products that have fueled the growth of the global economy for the last couple decades. They are aware of others' efforts to exploit the new technologies, and they fully intend not to get left out again.

The natural tendency in such a situation is to throw money at the problem. And that, given their size and financial strength (based largely upon commodity exports) , they have indeed committed to do[180]. The Federal government advertises its current level of support for science and innovation as $4.7B[181], comprising $1.3B in major federal research institutions (CSIRO,

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[178]Australia's higher education system essentially has a three-year baccalaureate program, supplemented by a fourth 'honors' (research) year. There are also a variety of certificate and other programs. At the graduate level, there are both class-based and research Masters, and the PhD; and neither of the latter two degrees usually requires any classroom work at all. The focus of postgraduate programs is quite clearly stated in the use of the term "training", as opposed to "education" for both the research Masters and the PhD.

[179]*BAA*, for example, is the result of a series of innovation-oriented initiatives of the current government. These started with *Investing in Growth* in Dec 97, followed in Dec 99 by the higher education white paper, *Knowledge and Innovation*, and a Discussion Paper authored by ISR Chief Scientist Dr Robin Batterham, as a prelude to a National Innovation Summit in Feb 2000. This was followed in turn by the Summit Implementation Group's *Innovation - Unlocking the Future*, and in Nov 2000 the Chief Scientist's report, *The Chance to Change*. *BAA* is the resulting 5-year strategy, released early in 2001, not coincidentally a prelude to the Nov 2001 election. It's also worth noting from the titles of these papers that Australian politicians seem to love slogans, and apply them to their policy statements and programmes in much the same way the Americans name their military campaigns; and probably for many of the same reasons.

[180]This raises the interesting question of whether they have enough top talent to spend it all well -- even assuming, which I don't -- that the money is going in a more or less correct direction. Many would argue that they do not.

[181]All dollar figures are in Australian dollars - divide by 2 to get a rough estimate in US $.

DSTO, etc[182]), $0.7B in "S&T Support" (NHMRC, CRCs. rural research, etc), $0.8B in support for the private sector (R&D Start, COMET, etc, and an estimate of the value of the 125% R&D tax concession), and $1.9B in university research (ARC and other, including the research component of university operating grants)[183].

To this, the Government has pledged, via *BAA*, an additional $2.9B over the next five years. Although I have some trouble adding their figures to reach that precise number, the major elements of the program are:

- $2.313B for 'strengthening our ability to generate ideas and undertake research'
  - $736 M to double ARC's competitive programs (including the new Federation Fellowships[184]); an additional $336M for project specific and $246M for basic university research infrastructure; $176M for Centres of Excellence in ICT ($129.5M) and BT ($47M); $155M for 15 new Major National Research Facilities[185]; $535M for R&D Start (cost sharing grants to small companies), and an estimated $128M in additional R&D tax concessions and rebates[186].
- $487M for 'accelerating the commercial application of ideas':
  - $227M additional for the Cooperative Research Centres (CRCs), $40M to double the Commercializing Emerging Technologies (COMET -- improving commercialization skills) programme, $100M for 'innovation access', $78.7M as pre-seed funding via universities and public sector research agencies; $20M to double the BT innovation fund, and $21.7M for new agribusiness products and services.
- $350M for 'developing and retaining Australian skills'
  - $151M for 2000 new university places each year (60% reserved for ICT, math and science), plus an additional 670 places in 'regional' campuses[187]; $130M for school-based innovation in science, math and technology; $34M for online curriculum development; and $35M for the National Innovation Strategy, including measurement of success.

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[182]CSIRO receives $615M/yr direct government funding, augmented by about another $300M from 'customers', and has ~6400 staff. DSTO receives ~$250M and has 2100 employees; in the future its funding will be 2% of the Defence budget.

[183]*Backing Australia's Ability*, p19. What is left unstated in the 'propaganda' literature is how the calculations are made...e.g., I was told that they count 1/3 of all university faculty salaries as research...this is an interesting component of the $1.9B, especially in comparison to ARC's 01-02 budget of just $270M.

[184]Twenty five of these, each worth $225K/year for five years, will be offered to attract or retain the best and brightest. What's not mentioned is, what happens when the incumbents' salaries return to normal (about half what the Fellowship offers) in year 6? Of the first fifteen, seven are currently overseas; and thirteen including those seven will be going to Group of Eight Universities (the old, prestige universities). I had the pleasure of meeting two of the recipients during my visits.

[185]Nine in Melbourne, 5 in Adelaide, 4 each in Brisbane, Sydney and Perth, and 1 each in Armidale (NSW), Canberra (ACT), Darwin (NT), Launceston (Tasmania), Merbein (Victoria), Parkes (NSW), and Wagga (NSW). Everybody gets something, and the rich get richer. The one that attracted the most comment was the Australian Synchrotron Research Program, for which Victoria put up $100M, outbidding Queensland's $67M (if I have my numbers right...). The largest, at $23.5M, is for "Gemini and SKA: Australia's Astronomy Future", capitalizing on two of the nation's competitive advantages in that field, lots of land and clear, southern hemisphere skies (their third advantage is an already world class capability).

[186]Australia offers a 125% R&D tax concession which can be claimed on a company's tax return; *BAA* added a 175% concession for additional R&D investment, targeting labor-related components of R&D; plus a rebate for up to 1300 qualifying small companies that are at a tax loss.

[187]NSW: 550 'BAA' + 180 Regional; Queensland: 520 + 315; SA: 165 + 20; Tasmania: 65 + 20; Victoria: 430 + 45; WA: 270 + 90; plus 30 at new regional delivery sites in WA & Qld. None in NT and, interestingly, none at the nation's premier research university ANU in Canberra ACT (few votes there)!

Although not directly part of BAA, Australia also boasts an innovation-supporting regulatory framework, tax reforms including a new goods and service tax (which occasioned considerable grumbling among many of my contacts), low company tax rate (max 30%), a recently reduced capital gains tax, and in general quite an open economy, including competition in previously public monopoly sectors such as telecommunications. All things considered, except for the tiny market and long distances, Australia does, as *BAA* claims, have a "dynamic and competitive economic environment with high growth, low inflation and high productivity".

K&I notes that a strong research base underlies the current two revolutions in S&T, ICT and BT. It also notes that Australia is third in the 17 OECD countries in public investment as a percentage of GDP in R&D in government and higher education, but 11th in terms of business R&D expenditure. It therefore establishes goals of strengthening basic research (paying at least lip service to the engine of progress -- it's there, but not emphasized) and encouraging the universities to focus on their areas of particular excellence, while increasing the exchange of knowledge between researchers and the users of the research, rewarding partnerships, and promoting entrepreneurship among the researchers and students (or rather, 'research trainees'...the objective is to reduce completion times, increase the % of successful completions, and prepare the 'trainees' for employment).

The principles upon which the policy measures are to be based include excellence plus concentration of resources to build critical mass; institutional autonomy to let the Universities set their own priorities and manage their own research activities, thus leading to a diversity of strengths and approaches[188]; student choice in where and with whom they work and how they do their research; linkage and collaboration, nationally and internationally; university policies to facilitate commercialization and develop "an entrepreneurial culture among researchers"; and transparency, contestability, and accountability. While some of this is inevitable (yet highly appropriate, even essential) rhetoric for higher education research policy, perhaps the key points are the focus on critical mass, emphasis upon commercialization[189], and (deliberate) lack of strategic direction with respect to preferred disciplines or areas of research[190].

As opposed to *BAA*, *K&I* does not address funding directly (actually university funding has declined considerably over the past decade), but rather specifies three sets of measures to help achieve its goals. The first is to strengthen the role of the Australian Research Council (ARC) by giving it independence under a CEO who will be assisted by a set of professional programme managers. ARC is to provide strategic advice to the government about research in the university

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[188]Approaches, perhaps...but while there are variations on a theme, IT and BT rank pretty high on the list of all the universities I visited, not surprising given the global and Commonwealth emphasis. Other favorites include environment, medicine and psychology. Actually there is quite a bit of positioning and competition among the Universities to attract students, and everybody has glossy brochures, albeit the majority of students still end up attending a school near home. All the 'marketing' seems to be for a mix of impressing the funders, and attracting fee paying international students, an important source of income.

[189]As I will discuss further below, the Universities I visited have indeed taken this charge seriously, and all have major efforts, under their Deputy or Pro Vice Chancellors for Research, to increase their linkage to industry, and develop and exploit their intellectual property. More than once, however, it was pointed out to me that while everyone is 'commercializing', there is a significant lack of adequate expertise in the requisite business and IP areas. While there are some notable successes, there's lots of wasted effort, lots of amateur entrepreneurialism, and not much in the way of 'training' to enhance the business skills of either the administrators or the researchers.

[190]One of the results is that certain important fields, like math, physics, and engineering, suffer. The policy being propounded here is for research, not education per se; but given the 'reward' formula for Universities -- since the term is synonymous with 'Research Universities' -- the two are inextricably linked. More on this below.

sector, help form linkages between researchers and other communities, encourage consortia and sharing of infrastructure, develop public appreciation for the contributions of research, and report on competitive performance. ARC is to manage a two element National Competitive Grant Programme, consolidating multiple current programs into Discovery and Linkage Grants. The second subdivides the Institutional Grant Scheme into two performance based parts, block grants for general research and research training, and grants for research training scholarships; it specifies a formula for each, rewarding the universities for the number of research students it graduates (output; MS degrees are to be no more than 2 years, PhD less than 4), the research income it receives from competitive grants (taken to be a measure of capacity), and publications (weighted 30-60-10 for the block grant, and 50-40-10 for scholarships)[191]. There is also provision for minor support to the thirteen 'regional' universities to help them adjust to the new system. Finally, *K&I* requires the universities to develop and submit research and research training management plans, outlining their strategy for commercialization, strengths, QA plans, etc., to help ensure accountability against 'objective output measures'.

Defence 2000: As significant as the Defence White Paper is by itself, it is even more so when taken in conjunction with the series of Defence administration and management reforms that started before it -- as the Minister says in his forward, to "demonstrate to taxpayers that the additional funding provided to Defence would be managed wisely" -- and can be expected to continue for some time[192]. Since the WP is better known to much of my US audience than the other policy statements I am covering here, I'll just briefly summarize its major provisions.

Essentially, *Defence 2000* commits the nation to maintain its maritime capabilities (air and naval forces) to deny the approaches to the nation to potentially hostile forces, plus land forces (and the ability to deploy and sustain them) capable of joint operations and defense of the homeland. Other missions can then be performed by forces designed and sized for these principal tasks. Force maintenance and augmentation to achieve the WP's objectives will require about a 3%/year growth in Defence funding over the decade, from the 00-01 level of $12.2B, to about $16B; in real terms, this equates to an increase in Defence spending of ~$23.5B over the next 10 years.

Dealing more specifically with maritime forces, the major changes include upgrading the new ANZACs with improved ASM capabilities, building at least 3 long-range air defense ships and two new supply ships, upgrading the Collins class platform characteristics and combat system and acquiring a new heavyweight torpedo, refurbishing or replacing the 19 P3Cs, and building about 15 of a new class of Patrol Boat. For the Australian shipbuilding industry, this means a commitment to replace almost all of the fleet: in addition to the ANZAC and Collins builds which are still underway (plus maintenance and refit), 3 new combatants, two new supply

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[191]The precise formula is somewhat more complicated and detailed, and can vary from year to year, but this gives the general idea. The policy also allows ANU's Institute of Applied Science to buy-in to the competitive scheme process by allocating 20% of its block grant to the competitive process.

[192]The problems with the Collins Class submarines, and the JORN OTH radars, are rather classic cases of what can go wrong in major defence acquisitions. These failures, combined with analysis of changes being undertaken by e.g. the US and UK, impelled a major process of rethinking and reorganization. Some of the hardest calls have yet to be made, however, as Australia embarks on the significant R&D and acquisition programs outlined in the WP. In my view, the most important choices to be made are precisely what indigenous defence industrial capabilities Australia desires to have. The Minister's 26 June 2001 paper presented to the Defence National Procurement Conference, "Australia Needs a Strategic Approach to Defence Industry Policy", recognizes this point. My discussions with a number of SMEs, however, plus the seeming emphasis on dealing principally with the primes, leaves me less than sanguine that Australia recognizes its strengths or is structurally capable of enhancing them. More on this below.

ships, and 15 PBs. Significant but, as the Minister notes in his June 01 speech[193], hardly enough to sustain the current number of yards (3 major, numerous smaller shipbuilders). Thus, two key aspects of acquisition reform are industrial rationalization (industry led...but prompted in this case by the government's sale of ASC), and structuring the new acquisitions -- along with maintenance and refit -- for a stable industrial base. Overall, the Minister proposes 'alliance contracting' with the minimum number of primes needed to maintain Australia's essential capabilities[194] ("six locally based companies --many of which are the overseas arms of increasingly successful and truly international defence companies, dominate our prime contract business"), and notes the importance of becoming part of the global supply chain rather than relying on the small Australian market. He also emphasizes the need for international companies and DSTO[195] both doing more to nurture Australian SMEs.

The WP charge to DSTO is worth further note. It states (p 108) "the most important development changing the conduct of warfare is the ability to vastly increase the speed and capacity to collect, organize, store, process, tailor and distribute information. This development ... has led to what is generally known as the Revolution in Military Affairs (RMA)". RMA increases the importance of new skills, training, and organizational structure, and of cooperative programs with the US, both in IT per se and space based systems. DSTO is expected to contribute a significant part of Australia's component in the international cooperation, also to work with industry to build IT capabilities for improved command systems, 'just in time logistics', precision weapons, and network-based operations. Other new-technology priorities for DSTO include electric propulsion, the support of technology-empowered individuals and small groups, and modeling and simulation for planning and training. DSTO's centre of expertise in combat systems in support of the Collins class "will be expanded to include other maritime and air combat systems with an enhanced role for DSTO in support of system upgrades". Advances in BT, nano-technology, and new materials and structures will be 'watched' for their potential, then adapted to military use; Australia (DSTO) must have this ability in "selected niche areas", and must also be able to understand how to use the new technologies in the environments (e.g., humid tropics) where their forces operate. Equally important, DSTO must maintain its "reputation as a world leader in extending the service life of aircraft... [and its] traditional but vital S&T expertise in areas such as aircraft and ship structures". Overall, DSTO "must be able to assess overseas trends, develop new technologies where appropriate, and build strong linkages with industry...[and] play its part in...innovation in the wider research and development community and industry". The WP charges DSTO to review its program of work and structure to ensure it can simultaneously take advantage of emerging technologies and retain essential technological strengths. One apparent response to this charge is the very recent reorganization into three laboratories, one each for Information Systems, Electronics Systems (and weapons), and Military Platforms.

Finally, of great importance for Navy (and ONR), the WP has been recently complemented by the "Statement of Principles for Enhanced Cooperation between the United States Navy and the Royal Australian Navy in matters Relating to Submarines". Indeed this agreement is the proximate cause of our strong interest in stationing a ship technology expert in

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[193]Ibid. See also the Defence & Industry Strategic Policy Statement of 1998

[194]The WP states the critical defence industrial capabilities as combat systems software and support, data management and signal processing, C3 systems, systems integration, and repair, maintenance and upgrade of major weapons and surveillance platforms. One major implication is that in cooperative programs, Australia will insist on access to source codes; thus releasability is a critical upfront issue for any collaborative effort. This point was strongly reemphasized in my discussions with the Chief of Navy.

[195]Universities are peripherally mentioned with regard to DSTO, but the clear message is that it's the relationship to industry, and particularly SMEs, that needs work. The ones I talked to would certainly agree. More below.

Melbourne to work closely with DSTO. The rationale for the agreement states our mutual desire to "seek to achieve the maximum interoperability and synergy of effort". Joint training and exercises, plus exchange of data and associated 'exhaustive analysis' "will form the stimulus for research and development". In addition to encouraging information exchange and facilitating mutual access to facilities and personnel, our two Navies agree to cooperate in RD&E in improving acoustic characteristics and combat systems, and "projects to develop improvements jointly for software updates for a common combat system. The USN and RAN intend to maximize convergence on software improvements with a goal of ensuring a USN/RAN common baseline..." This is a major new strategic alignment, the impact of which was particularly felt in Australia's cancellation of competitive procurements for the new Collins combat system and heavyweight torpedo. It is largely because this new level of cooperation will require us to work much more closely in S&T, that it is important for us to try to understand Australia's innovation system (thus this paper), and where appropriate consider changes to our own Defence Cooperation in Armaments procedures (e.g., truly joint developments, with cost sharing, up-front openly negotiated agreement on releasability, source codes, and IP, and reliance on the others' university, industry, and defence lab expertise; this is addressed in my overall introduction).

Australia's Ocean Policy, promulgated in December 1998, recognizes that ecosystem health and integrity is fundamental to ecologically sustainable development of the nation's huge marine area, and in turn to the strength of marine industries, which (according to the *Marine S&T Plan* released a year later) contribute about 9% of GDP. The policy applies to "Australia's Marine Jurisdiction"[196]; the coastal zone is the responsibility of the States. Because there is no overarching Marine agency (as in most countries), the Policy establishes an oversight mechanism comprising the National Oceans Ministerial Board[197], and a National Oceans Advisory Group that reports to it. It also sets up an Executive Agency, the National Oceans Office[198] (in Environment Australia) that coordinates the development of the core element of the policy, regional marine plans. The Office also serves as the main point of contact between the Commonwealth, States and Territories, provides information to stakeholders, and is responsible to NOMB for the overall implementation and further development of the policy. In addition to the regional marine plans, the Policy also prescribes 'specific sectorial measures' for some 20 areas, including e.g. marine biological diversity, shipping, pollution, and indigenous marine interests. Among the overall objectives are development and improved management of marine protected areas, national standards for marine and estuarine water quality, a single national ballast water management system, trials to treat acid-sulfate soil areas, a national moorings program for sensitive areas, and support for early phased withdrawal of toxic anti-fouling paints. Worthy objectives all.

In practical terms, the National Oceans Office focuses on the development of the Regional Marine Plans, for which the government provided $50M over three years (no other funds were provided for any other element of the Policy, or for the accompanying Marine S&T Plan, or as far as I know for Marine Industry Development Strategy which was released in 1997)[199]. The regions are based on the concept of Large Marine Ecosystems, and there are seven of them around the mainland, plus the Australian Antarctic LME and several others around the

[196]AMJ comprises the EEZ -- 8.6 million square kilometers around the mainland, and an additional 2.4m sq km off Antarctica, plus an additional 5.1m sq km of extended continental shelf claimable (by 2004) under UNCLOS.

[197]Chaired by the Minister of Environment; reps from Ministries of Environment and Heritage, Industry Science and Resources, Sports and Tourism, Transport and Regional Services, and Fisheries. Not Defence.

[198]I was scheduled to visit this office but my appointment was cancelled.

[199]The web site also has a section about a Coastal and Marine Planning Programme, which offers 'targeted opportunities' to help local and state governments improve the quality of their plans.

islands. The first plan to be developed is for the SE region, comprising the waters off Victoria, Tasmania, southern NSW, and eastern South Australia. Since the LMEs cross jurisdictional lines (scientifically sound, politically problematic), the States have not 'bought in' to the process, so the plans (and associated data collection) are focusing principally on the outer shelf and slope.

In accordance with the policy, a working group from industry, academia and government[200] spent the next year preparing the *Marine S&T Plan* which provides "a strategy for integrated and innovative S&T...a key to better understanding of the marine environment and its living, mineral and energy resources; and an effective framework for well focused, concerted action..."[201] by the various members of the community. Reflecting the diversity of marine interests, the Plan sets out 29 objectives, each with its own priorities and strategies, under three Programs (Understanding the Marine Environment, Using and Caring for the Marine Environment, and Infrastructure for Understanding and Utilizing the Marine Environment). Although no funds have been provided for implementing the plan -- and indeed one can argue that it would be impossible to comprehensively address such a huge menu -- some of the specific recommendations have been addressed through other programs[202]. Overall, however, I found little evidence that the many organizations involved are undertaking "well focused, concerted action" in accordance with their own framework.

In summary, over the last few years the Howard Government has done a very creditable job of setting out its intent and strategies in many of the aspects of S&T with which I have been most concerned. One can argue with the outcomes, quibble about the rhetoric, or point out gaps and deficiencies, but at least it's quite clear where Australia is headed. Further, given the nature of the process, the path by which the decisions were made is traceable; and the government has made the information readily accessible on the web.

Sponsors and Mechanisms: I'll deal in turn with DETYA/HED and ARC, DISR and the CRCs, DOD (DMO and DSTO), and Others[203]

DETYA: The two elements of the Department of Education, Training and Youth Affairs with which I am concerned here are the Higher Education Division (HED), and the Australian Research Council (ARC). **HED**, headed by 1st Assistant Secretary Mike Gallagher, is perceived by the Universities more as a bureaucracy anxious not to be captured by its constituency, than as

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[200]But NOT the DOD or RAN, in spite of specific interests and responsibilities, such as hydrography and AODC

[201]Goals are stated in *Australia's Marine Science and Technology Plan -- An Overview*, 1999, p5

[202]E.g., in infrastructure, the desire for new hydrodynamic design and test facilities, and a research facility for the Timor-Arafura Sea region, were met by MNRF awards; one can presume the proponents for these facilities quoted the Plan in their bids. Similarly, ISR Chief Scientist Robin Batterham's recently released review of Tropical Marine Research will lead to support for upgrading the island research stations. Some progress has also been made in marine data management, largely through the efforts of a group under the Heads of Marine Agencies (which has otherwise not been very effective since it has no resources and no official charter). However the blue-water research vessel situation is critically weak (CSIRO is selling one of the national ships to be able to upgrade and operate the other), and the only momentum toward a long term monitoring system seems to be coming from Western Australia, where it is could be of use to the offshore oil and gas industry. More below.

[203]The government reshuffled on 26 November. DETYA is now the Department of Education, Science and Training, DEST, and DISR is Industry, Tourism and Resources, DITR. I am blithely ignoring this reality, since although the portfolios change, the constituent elements remain; also, although the important shift of CSIRO, AIMS and ANSTO to the DEST portfolio sets the stage for some potentially important strategy changes, I have no way of predicting what these may be.

a forceful advocate of the their interests. Its principal function is administration of the institutional funding programs, the associated development of cost management and quality assurance practices, and collection and analysis of statistics. Funding schemes are currently in a transition period due to the changes associated with *K&I* and *BAA*, but essentially the Commonwealth, under the Higher Education Act, funds 38 universities on a rolling triennial basis. It supports two others on an annual contract basis, and there are only 2 private universities; so for all practical purposes, Australia has a federally funded higher education system.

Each university receives a single block operating grant, based on the total number of students places an institution is expected to deliver (weighted by discipline and level...e.g., a lab course like chemistry gets more than a non-lab one like math or English). Allocations are based upon annual discussions between DETYA and the university, based in turn upon that institution's Educational Profile, which comprises statistical information on its teaching activities, and several management plans[204]. In addition, students contribute to costs via the Higher Education Compensation Scheme (HECS)[205]. In 2001, the commonwealth funded 367,365 undergraduate places (full time equivalent), and also marginally funded an additional 25K students above the agreed targets. Total operating grant costs were $5.397B. The institution is essentially free to apply its operating block grant in whatever way its believes best, but generally allocates its funds to Faculties and Schools in proportion to the manner in which the grant was determined[206].

In addition to the basic block operating grant, under the new rules laid out in *K&I*, DETYA manages "formula driven schemes" for research and research training ($213M in 01), and research infrastructure ($82M '01), which complement the "application based schemes" managed by ARC ($248M 01). The Institutional Grants Scheme (IGS) supports the "general fabric of research and research training", with allocations based 60% on the amount of research income the university attracts (all sources weighted equally; this is a recent change from the previous scheme where ARC grants received double weighting, and reflects the strategic emphasis upon commercialization and relationships with industry), 30% on research student load (with a 2.35:1 weighting of 'high cost' vs 'low cost' places), and 10% on publications (books weighted 5, and chapters, journal articles and conference papers 1; in 2003, this will change, to include patents -- weight 2 -- refereed designs and exhibited works, again reflecting the emphasis on IP and commercialization). . There is also a Research Training Scheme (RTS) which supports research MS and PhD scholarships[207] for 21,644 places in 2001, with allocations to universities based 50% on the number of students completing degrees (weighted 2:1 for PhD:Masters), 40% on research income, and 10% publications. Research Infrastructure Block Grants (funded at 20

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[204]Research and Research Training, QA and Improvement, equity, indigenous education, and capital management. DETYA/HED's web site states that information from the Educational Profiles and other statistical surveys "facilitates a review of an institution's performance in achieving previously agreed objectives and forms a basis for assessing the resources needed by the institution".

[205]Costs are related to the course: about $3500 a year for arts and education, $5000 for math, computing, environment, science and engineering, and $5870 for law and medicine. Students can also of course go to a private school which costs up to about $10K/year, or pay roughly comparable full fees to one of the Commonwealth supported universities, should they want badly enough to attend a school and course whose government subsidized places are already filled (entry is test score based).

[206]Recalling the principles laid out in *K&I*, albeit they were supposed to be for research, the Universities try to design programs that will attract the best students it can get given its allocation of places (and also will try to attract more to increase its allocation). The system is thus somewhat 'market driven', in that student interest or lack thereof will over time impact allocations to various disciplines. Given the drive for jobs and 'practical' training, and the emphasis on and hype about IT, this has meant in practice that some of the 'hard' subjects like physics and math have been badly hurt; in some cases, whole Departments have been wiped out. More on this below.

[207]actually, HECS-exempt Higher Degree Research Places, up to 4 years for the PhD and 2 for the Masters

cents for each dollar of competitive research grant funding, $82M in 2001) are made in proportion to income from Australian competitive grants, and will likely be integrated into the IGS after 2002[208]. There is also a provision, funded at $6M, that the 13 'regional' universities will not suffer during the transition to the new procedures.

ARC and its now-CEO Prof. Vicki Sara received high grades from virtually everyone I talked to. The ARC Act of 2001 is considered a major victory since it considerably distances the organization from the politicians and DETYA bureaucrats. Until 1998, as one of seven 'councils' in DETYA, ARC played no real role in the innovation system, serving essentially as a 'mailbox' for grants. Over the last four years, culminating in its new charter, it has started to act more as a broker for research, both with the government as a whole and with other elements of the system such as CSIRO[209]. Policy advice to and coordination within the government is now part of its job, and since S&T is at last "on the radar", it's time to start to discuss priorities and targeted funding, which has previously been impossible. Of course as an independent agency ARC is now responsible (to its Board, then the Minister) for its own administration and the full management of its programmes, so its work load has increased considerably.

One of the most immediately obvious facts about ARC is the small size of its budget compared to what we think of for places like NSF and ONR in the US. Even though its funding is set to double over the next five years ($270M to $540M[210]) it is still tiny by US standards, and the new Federation Fellowships have to come out of the increase, so not all the new money will go to peer reviewed grants. This deficiency is somewhat alleviated by the fact that faculty salaries, infrastructure, and most overhead are covered via DETYA's operating block grants, so ARC pays only the 'direct' cost of its projects. Still, however, its resources even at the end of the growth period will probably equate in buying power about to what ONR has in basic and applied research; and it must be remembered that (with the exception of NHMRC), ARC is virtually the only source of competitive research grants in the country, and it covers the creative arts as well as humanities, science and engineering.

A less obvious but nonetheless important role for ARC is its intellectual leadership and coalescing power among academics. It the past, in addition to the "Council" per se, ARC has had a number of panels to help in coordinating reviews and discussing programmes. Participation on these panels gave the participants closer contact to their colleagues around the country, and involved them in federal as well as their state and local interests. I selected most of my points of

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[208]This year's data averages over 1998 and 1999 awards, and is interesting in portraying the relative success of various institutions and groupings of institutions. The Group of Eight Universities (Universities of Melbourne, Sydney, NSW, Queensland, Western Australia, and Adelaide, Monash Univ & ANU) together received over 70% of the competitive grant funds; of these, the top four (M at $10.7M out of the total $82, S-$9.4, NSW-$8.9, Q-$8.3) themselves got 45%. It should be noted that this is from the period before ANU's IAS became eligible to 'buy in', so its contribution is deceptively low. A second grouping of five (Macquarie, Newcastle, La Trobe, Flinders and Univ of Tasmania) together got slightly less than Melbourne alone for 12.3%, and a third group (Univ of New England, West Sydney, Central Queensland, James Cook and Murdoch) accounted for $5.8 -- about the same as the Univ of Adelaide, or 7.1%. So, less than half the total number of Universities accounted for 90% of the competitive grant awards.

[209]During this period, alone and with the consultants and CSIRO, ARC produced a number of reports that were critical in getting the government to acknowledge the role of publicly funded S&T in the nation's economy and security. See report 8 for citations to a couple of the more important. The vision they promoted -- Research in the National Interest: Enabling the Future -- is now on the top of the ARC calling cards; and ARC's Strategic Plan, "Investing in our Future", notes, inter alia, that 95% of Australian research papers cited in Australian-invented US patents originated from publicly funded research, compared to 73% overall in US patents. Of course, one might cynically note that one of Australia's major failings is the very poor record of industrial investment in R&D, so this is hardly surprising.

[210]The Act provides for maximum funding of $247.8M in 01, $270.4M in 02, and $339.2M in 03

contact at the Universities from the membership of these panels, and can attest to the broadened perspective of those individuals compared to staff and faculty who had not had such an opportunity. Going forward, each of the six Executive Directors will be assisted by a Expert Advisory Committee, so this important 'national consciousness' aspect of ARC's activities should continue. Having the 'clusters'[211] each managed by a professional (seconded for up to three years from CSIRO or a university) should also help shape the overall national agenda.

As noted above, under the aegis of *BAA* and *K&I*, ARC's premier programs, competitive research grants, now fall in two categories: Discovery, and Linkage[212]. Project grants in both categories can now be up to five years (previously 3), at levels from $20K-$500K per year, but any investigator is restricted to no more than 2 grants simultaneously. Discovery project grants combine research (ranked 40% on track record of the investigator, 30% significance and degree of innovation, 20% approach, and 10% national benefit) and research fellowships (60% track record, 40% project quality). Linkage project grants can be either for joint industry/academic research, or for an Postdoctoral Fellowship in industry only (APAI; for graduates with less than three years of postdoc experience), and are rated 20% on investigators track records, 25% project significance, 20% approach, 10% national benefit, and 25% the industrial partner's commitment. Success rate for the 02 Discovery grants was 23.3% (ranging from 20.7-24.6% across the disciplines), with an average of 74.7% of requested funds awarded (range 61.6-81.9%). Linkage success rates were considerably higher, averaging 53.1% for projects and 49.8% for APAI only. Prof Sara noted in her discussions with me that she would like to increase Discovery success rates to about the 1/3 as opposed to 1/5 level, and would prefer that ARC pay 100% of the direct costs of the research. This latter is a bit of a problem since the universities all use somewhat different accounting procedures (any system can be gamed...), and she is trying to get the researchers to fully price their proposals[213].

Beyond the competitive grants, ARC now also plays a very significant role in the major national "Centre" type programmes. The CEO has a seat at the table for selection of CRCs. More importantly, ARC is a co-investor with others in the Centres of Excellence initiatives; with DISR in the BT COE ($46.5M over 5 years), the National Office for the Information Economy for the ICT COE ($129.5M through '06), and with the Grains Research and Development Corporation for the Australian Research Centre for Plant Functional Genomics. Overall, the universities expect that government support will be evolving over the next few years toward more larger 'critical mass' type projects and programmes, in consonance with policy. Examples of these include ARC's very competitive and highly successful National Key Centres for Research

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[211]The six clusters are: Humanities and Creative Arts; Engineering and Environmental Sciences; Social Behaviour and Economic Sciences; Mathematics, Information and Communication Sciences; Biological Sciences and Biotechnology; and Physical and Earth Sciences

[212]There are of course subdivisions...Discovery has project grants and Indigenous Researchers Development, and Linkage has Project, Infrastructure, and International Categories. I'll discuss only the Project grants

[213]I haven't done a detailed analysis of the results of the 02 awards, but a quick glance indicated that the Group of Eight again did well, although with considerable variance across the members -- from Monash's 19% success with an 02-05 allocation of $7.7M, to University of Sydney's 30% and $25.7M. ANU-IAS, allowed to compete for the first time this year, got 27.1%, $5.6 compared to ANU's 29.3%, $13.5M, albeit these figures are biased by the rules that allowed IAS to win only a small percentage above what they contributed, and IAS significantly outperformed their ANU colleagues in Linkage grants. In other Linkage awards, there was again a big range in the G8, from Univ Adelaide's 32.1% for $0.9M with an industrial commitment of $0.8M, to U Melbourne's 69.4%, $6.7/$9.0M and UNSW's 68.1%, $7.1/$9.2M. One very strong performer was one of the 'regional' universities, Newcastle, that had a Discovery 33%, $7.5M and Linkage 76.2%, $2.1/$3.2M score, and associated bragging rights. James Cook also did very well, with 37.8%, $5.4M, and 66.7%, $1.1/$1.2M.

and Training (postgraduate), and Special Research Centres (no educational component required). While remaining the bastion for peer reviewed excellence in basic research (which continues to underlie all the hype about commercialization, or so one hopes), ARC thus stands to become an ever more powerful force in defining the priorities, direction, and nature of Australian research. It will be interesting to watch it evolve and exert its new independence over the next few years.

DISR: In addition to its strong role in innovation policy, DISR (and its powerful Minister, Senator Nick Minchin[214]) is important to S&T both because three of the major federal performers -- CSIRO, AIMS and ANSTO -- are under its aegis (the first two of these are discussed below, in the Performers section), and because through AusIndustry it manages industrial R&D tax and grant programs, the Major National Research Facility programme, and the extremely important Cooperative Research Centres programme (which I discuss separately below). AusIndustry has several categories of general industrial incentive programs[215]:

- Under the "Innovation" category are:
  - R&D Tax Concession. Industry is offered a broad based, permanent concession of up to 125% of R&D expenditures, claimable as part of the tax return. *BAA* provided an additional, 175% premium (incremental) concession for additional R&D, for industries with a three year history of claiming the 125%, or for those who receive R&D Start grants. SMEs with a tax loss acan get an R&D rebate.
  - R&D Start provides merit based grants and loans (up to $15M but generally $100K-$5M) for R&D and commercialization. Core grants, for companies with turnover <$50M provide up to 50% of costs; Start Plus grants for larger companies provide up to 20%; and Start Premium provides an additional reimbursable loan up to a total of 56.5%. There is also a separate Start program for graduate students.
  - the Biotechnology Innovation Fund, originally $20M over 3 years but doubled by *BAA*, which provides merit based matching grants of up to $250K to reduce the cost of 'proof of concept' or new products. Some States have matching grant opportunities.
  - the Innovation Access Program, $100M over 5 years (*BAA* again) to increase access to global R&T through consultations and workshops, and with competitive funding for global specialist assistance, overseas study, and international demonstration of Australian products.
  - the MNRF's $155M <50% match, over 5 years, previously discussed
  - The CRCs, discussed more fully below
- There are also several Venture Capital Funds. Of particular interest for S&T are:
  - COMET, Commercializing Early Technologies, for individuals, early growth stage companies, and research organization spin-offs, up to $100K (generally $20-$50K) for 80% of the cost of 'business advisors' to help develop tailored assistance plans
  - the Innovation Investment Fund, $220.7M Commonwealth plus $137.35M private funds, managed by 9 fund investors in 2 rounds, for start-up, seed, and early expansion funding. In round 1, by the end of April 01, $100M of the $195 available had been invested in 40 companies[216].
  - The Pre Seed Fund, a $72.7M *BAA* initiative providing a 3:1 Commonwealth:private match with universities and Commonwealth research agencies for commercialization of public sector R&D, to develop management and entrepreneurial skills.

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[214]It is notable that he, and not the Education Minister, presented the Commonwealth Government's Science Prizes for Achievement in Physical and Life Sciences at the PM's Prize for Science Dinner on 25 Sept. On 26 Nov 01, Sen Ian MacFarlane took over as Minister for Industry, Tourism and Resources, & Sen Minchin picked up the portfolio for Finance and Administration.

[215]In addition there are industry specific incentives for passenger motor vehicles, petroleum, printing, shipbuilding, textiles, clothing, and footwear

[216]15 in NSW, 17 in Victoria, 5 in Queensland, 2 in ACT and 1 in South Australia

The **Cooperative Research Centres** Programme, despite some debate regarding the uniformity of success and ultimate commercial output, has been perhaps the most important and far reaching of Australia's innovation initiatives. Started in 1990, with six subsequent selection rounds (and another coming up in '02), it provides some $140M/year in multiple (generally 7) year matching grants (<50%, averaging about 25%) to consortia of universities, public sector organizations (federal or state), and industries or their Associations[217]. The four basic tenets of the program are collaboration between researchers and users; a strong program of graduate education (research training); excellence in long term strategic research; and transfer of outputs into commercial or other outcomes of 'economic, environmental, or social benefit' to Australia. The CRCs are reviewed after year 2 to ensure they are on track.

To date, there have been about 90 CRC awards over the seven rounds, and as of 1 July this year 65 CRCs were active. CRCs involve two agreements, one among the participants which can take a variety of forms although they are 'encouraged' to incorporate and required to have an IP plan, and a standard agreement with the Commonwealth. There is a CRC organization that provides coordinated representation for member CRCs (most of them), composed of a CEO representative from each of the six major groupings (Manufacturing technology, ICT, Mining & Energy, Agriculture & Rural Based Manufacturing, Environment, and Medical S&T).

One of the CRCs' great strengths is their flexibility. They all have postgraduate students -- from a dozen or so to 90 -- but they can be centralized or dispersed, with full-time staff ranging from a few managers and administrators, to over a hundred scientists and engineers. Total funding over the grant period ranges from about $40M to almost $200M. Core participants can range in number from 4 or 5 to dozens, participants can be 'core' or 'associate', and contributions can come in both cash and kind. Most CRCs conduct their research at multiple locations, though typically much is done at Universities to get student and faculty support; and while all have an IP plan and in general the IP is shared, many have mechanisms to also conduct proprietary (or classified in the case of DSTO) research for their core participants.

During my visit, many organizations were actively preparing for the next round of bids. Provided one can gain the requisite degree of collaboration, CRCs have proven to be an excellent way of attaining critical mass and making rapid advances in important areas, so they are highly competitive. At least one, the Photonics CRC, has been credited with sparking a multi-billion dollar Australian industry and creating several spin-off companies, and several others have extremely strong industrial backing. The more 'public-good ' oriented CRCs are a bit more problematic, as they struggle to contend with the increased emphasis upon commercialization in relation to the other officially endorsed outputs desired from the program. Another concern is the Commonwealth funding profile which ramps down sharply in the last two years, somewhat complicating transition to independent status, or renewal (some are on their second renewal). Overall, for the 2002 round, the guidance is for increased opportunities for SMEs, international linkages and collaborative arrangements, and strength in innovation management. Objectives must be driven by user requirements, although it is recognized that for a new or emerging sectors, requirements may evolve[218]; but even if Australian industry is not strongly developed, active involvement is still sought. To alleviate some of the 'local jump start' difficulties, overseas companies can participate.

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[217]In the last round, 2000, the range of Commonwealth support was from $1.6M to $3.4M per year, with an average of ~$2.5M. With the extra funding provided through *BAA*, 03-04 funding is expected to reach $198M, with the next round (2002) average support being about ~$3M/year

[218]This appears to try to address one of the concerns, namely if commercialization and new business is so important, how can you use a CRC to start a new industry where none yet exists? Photonics, which had no industrial base at the start, is pointed to as an example.

The guidance is clear, however, that as even as the government's support of CRCs grows under *BAA,* industry's commitments are expected to increase, in cash as well as in kind; thus one concern is that at some point, the relatively small Commonwealth contribution will be inadequate to convince industry to cooperate, given the need to share the IP generated by the CRC[219]. To date, however, the mechanism has proven effective in attracting considerable industrial participation, and when an industry is able to take the lead in formulating a CRC, it can achieve excellent leverage both directly and through identification of expertise and training of highly skilled new recruits. It is also notable that CSIRO is a core participant in most of the CRCs (although in some, I was told, its contribution amounts mostly to handling the CRC's administration), and DSTO is in several. As I noted in my reports, CRCs offer ONR and other international sponsors an excellent way to tap into some of the most productive Australian technology, either through participation, or through funded development projects.

DOD: The Department of Defence has two principal sponsors of interest here, the newly created Defence Materiel Organization, and the Defence Science and Technology Organization. DMO is responsible for cradle-to grave acquisition and support of the systems and equipage of all three military services, and DSTO is responsible for their technical content. The military services also play a role, through the development of capability requirements, through formal as well as informal interaction with DSTO (e.g. the Navy Science Board, co- chaired by the Chief of Navy and the Chief Defence Scientist, for oversight of Navy related S&T), and directly through funding their own programs either in DSTO labs, or elsewhere when DSTO lacks expertise (e.g., the Ocean Analysis and Modeling System that RAN is sponsoring, together with BOM and CSIRO). I have described both organizations rather thoroughly in Reports 8 and 9, and the Defence 2000 WP discussion above covers much of their future direction. Thus I will just say a bit here about their role in the wider context of Australian innovation.

DMO can be expected to focus, at least for major new developments, principally on the (few) prime contractors. As noted in the Minister's June 01 speech quoted above, one of their major challenges will be to formulate an acquisition, refit and maintenance strategy that allows industry to rationalize and develop a sustainable capacity, as opposed to the past 'boom or bust' environment. Their second major task is to define more precisely those technologies and industrial capacities where Australia needs, or desires, to have a strong indigenous capability. This is a challenging task that will require considerable cooperation with industry and the rest of government (especially DISR), since the objective is to not only protect essential national capabilities, but also to integrate Australian companies into the global defence supply chain. The difficulty is compounded, to my mind, by an environment that has not in the past inspired or even rewarded industrial ingenuity in the Defence sector, but rather has looked overseas first even when nascent capability is available at home[220]. Further, Australia has made many significant errors in past acquisition; and while there is a lot of talk about the problems, and commitment to

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[219]Given the imperative for Universities to commercialize and generate spin-offs, they too are becoming somewhat reluctant to share IP...even when they are not very efficient at exploiting it financially, it provides leverage.

[220]This was a consistent complaint of many of the SMEs I visited; they feel rightly or wrongly that they have to prove capability by selling in the US or Europe, before their own system will consider their products. Further, although DSTO does support external work, it has done so largely in line with its own definition of both capability and requisite technical approach. The Capability Technology Demonstration Program enables industry to offer a system to be tried experimentally by the operational forces to evaluate performance against capability requirements, but industry has to pay for the development of the product to be tested, the program is quite small ($20M/year), the demonstration must be tied to an approved project, and success rate is low. Further, even if a demonstration is successful, during acquisition a prime contractor may select a different 2nd or 3rd tier supplier.

rectify past mistakes, it is not at all clear to me that there has been adequate dispassionate, academically based evaluation of the associated acquisition programs, to ensure that the problems have been properly diagnosed, let alone that the proposed fixes are suited to the nation's capabilities and culture[221]. Defence 2000 has indeed provided an opportunity for change in the form of sufficient resources to make a significant difference; at issue is the ability of the new materiel organization to make the right calls in a fairly short period of time. At best, they'll need a lot of help.

DSTO and its leadership can play a significant role in the process. The Chief Scientist has a strong background in ICT, one of the key technologies highlighted by Defence 2000, and he now sits on the PM's Science, Engineering and Innovation Council. His predecessor is now the Deputy Secretary for Strategy, further strengthening the S&T capacity and influence in the Department. Further, DSTO's direct income is set at 2% of the Defense budget[222], assuring steady growth for the next decade and enabling efficient long range planning; the labs have recently been reorganized to strengthen their responsiveness to the strengths demanded by the defence strategy; and they have a sound approach to experimentation as a central element in the introduction of new capabilities. From a Navy perspective, the USN-RAN agreement on submarine technology means much closer 'strategic' alignment, exchange of information, and R&D cooperation -- likely to spread to other areas such as AAW; and through TTCP and bilateral efforts, assisted considerably by modeling and simulation and 'virtual' capabilities, DSTO is poised to participate in a much more integral way in US developments and fleet experimentation.

At issue, at least to my mind, is DSTO's access to and support of the rest of Australia's innovation community. I am discussing them here with regard to their role as 'sponsor' and advisor, albeit their strength and heritage is as a performer; and indeed they have some capabilities, such as life extension, which are truly world class, as well as others that because of their sensitive nature are best performed internally[223]. DSTO does already interface with the academic and industrial communities, both directly and through participation in the CRC's. They were supporting some of the best university scientists I met, and in one case even had a DSTO employee playing a major research role directly in a scientist's lab. Further, the WP and the Minister's Defence industry policy speech both promote DSTO's support of SME. And, as I understand it, plans are to apply increases above the 10% flexible or 'blue sky' resources, to additional extramural research. My concern, which is no different from what I have for years argued in the US, is that when a performer simultaneously acts as a sponsor, there is an inherent restriction in approaches to meeting capabilities; this is one reason our Navy has kept ONR sponsorship separate from the research in the corporate or warfare system labs. A separate funding organization may well be a luxury Australia's DOD can not afford; but finding a way to encourage a multiplicity of approaches to a problem or opportunity has proven to be a key aspect of US technological and economic strength. Competition does indeed work to inspire innovation and ingenuity, and it needs to be promoted, not just tolerated, by management. It's not clear that DSTO is organized to promote such competition against its own preferred solutions, let alone that

[221]I'll admit to a bit of US bias here...but the independent case studies conducted by, e.g., MIT's Sloan School, or many other universities business schools, of both successes and failures have underpinned much of our own acquisition reform (for better or worse); and our flourishing management-advice market, although it contains a lot of hype, also includes some very scholarly studies of what has and hasn't worked in industry. I see nothing even remotely comparable in Australia.

[222]They also are funded by the Services for specific projects, for about 15-20% of their revenue

[223]Such, I was told, was the rationale for retaining the Defence in-house S&T capability, when all the other Ministries' labs were rolled up under CSIRO.

there are adequate mechanisms or resources to promote a significant growth in defence industrial innovation[224]. More on this below, with regard to other elements of Australia's system.

Others: While the Commonwealth organizations and mechanisms I have described so far are those with the largest impact overall on Australia's innovation system, a number of others play important if somewhat more circumscribed roles. The National Health and Medical Research Council, for example, has responsibilities similar to ARC's in its disciplines. It has a very rigorous peer review system, and is largely proposal-pressure driven but with a small component of 'strategically oriented' research. DOD contributes in the health arena through the Army Malaria Institute, and through Defence Health Service's proposed new Centre of Excellence that was attracting considerable academic interest during my visit.

Although except for DOD's DSTO most Commonwealth research is consolidated in CSIRO (and its 'sister' organizations, AIMS and ANSTO), all the Ministries have S&T and information needs and fund data collection, analysis, or R&D of some sort. Indeed, they are very important sponsors for many CSIRO labs, which are expected to raise about a third of their funding requirements from sources other than their direct grant. As noted above, DSTO supports the individual military services in much the same way. These federal organizations all also fund extramural programs of one form or another, albeit none (at least none that I encountered) are of any significant magnitude on the national scale. Some 'operational' organizations also have their own in-house R&D capability; the one of most importance for me was the Bureau of Meteorology Research Center, within BOM. It is an excellent example of a research unit that is very tightly linked to its most immediate user -- in this case the operational weather forecasters -- but at the same time, has generated a world class research capability and significant global role within its disciplines. BMRC also works closely with the CSIRO Atmospheric and Marine Divisions, and with the small and dispersed, yet quite capable, academic meteorological community[225]. Other notable examples of federal organizations that play a significant research role are AGSO-Geoscience which conducts much of the nation's geological and geographical research; and the Australian Antarctic Division, which manages the Antarctic science program, as well as the policy and logistic aspects of Australia's presence on that continent. I'd imagine that there are similar organizations in fields that I didn't focus on but are important to the country, not the least being agriculture and minerals.

States and regional organizations, such as the catchment basin authorities, also play a role. States in some cases have their own research organizations for products of importance regionally; the one example that I interacted with is the Tasmanian Institute of Agricultural Research. States also play a major role through incentive programs, both for attracting industry (research or industrial parks and the like) and for building capacity in various technical areas -- e.g. aerospace in Queensland, defence electronics around Adelaide, composites near Melbourne, marine industry south of Perth. And of course agriculture and minerals wherever they can be done/found. In many cases, given the fact that Australian labor is not cheap, technological capability, training and skills, and research capacity -- facilities and university faculty and

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[224]Like other Commonwealth sponsored research institutions, DSTO is expected to commercialize its inventions and IP. This may be fine as far as it goes, but such a 'tech push' from government into the commercial arena is a very far cry from encouraging competitive entrepreneurship in response to national needs.

[225] As discussed in Report 9 there was a CRC for Southern Hemisphere Meteorology, but it failed to achieve a second round; at issue is whether a CRC in an area where there are two strong Government research organizations provides enhanced capability, or inefficient competition, particularly when there is no clear role (yet at least) for a value-added industry. This may be a case where mechanisms like ARC's Key and Special Centres may be more appropriate for building critical mass in the academic community, if indeed such is needed or wanted by either the researchers or the nation.

students -- are significant players in the inducement packages. Offsets also play a role, on the state as well as federal level. As discussed above and in the reports, States and their incentives and priorities were very involved in the MNRF competition (the synchrotron being the most notable), and they will undoubtedly weigh in very heavily in the bids for the ICT and BT COE's. These two offerings, in fact, although in US terms quite small financially, have occasioned extremely spirited discussions and both collaborative and competitive deal making given the hoped for market potential. Victoria and Queensland are the major players here, while NSW has the advantage of existing capacity and industrial strength in the Sydney area.

Finally, industry itself is an important sponsor, in two ways. First, industrial R&D and associated productivity ultimately will make or break the country. Stimulating it is what *BAA* and the other government measures are all about, and as noted above Australia wants very badly to not miss out on what it expects to be the major market opportunities to come from ICT and BT. Value-added to Australia's commodities is also important -- thus the significant research investment in wool, wine, grains, forestry products, and minerals. Australia recognizes that its public:private R&D investment ratio is nearly opposite that of countries like the US and Japan, and understands that this can not continue indefinitely if it is to achieve the economic strength it desires. Thus at the bottom line, the name of the game is to stimulate industry to use Australia for a significant component of its research capability, even if it relies upon South Asia and similar locales for low labor cost manufacturing and assembly, and the major population centers and areas of business and financial expertise in the US, Europe, Hong Kong and Singapore, for marketing, sales, and finance. The CRCs are to my mind an excellent tool in this process; for relatively small government investment, the country not only gets the benefit of excellent research and education, and builds capacity, but simultaneously showcases its talents to industry, gives them a good ROI, and markets its graduates.

The second, more immediate importance of industry as a sponsor is more problematic in my mind. That is, that government views industry as an important sponsor of its own activity. CSIRO labs, for example, in addition to their role in commercialization, are supposed to bring in about a third of their income from the outside -- read industry. Apparently the premise is that, as with the CRCs, industry will take advantage of the leverage it gets against government funding, and pay the government labs to do their R&D. Universities, of course, are also directly offering their services, albeit in considerably different ways. However it's one thing for industries to collaborate in CRCs for all the reasons mentioned above -- not the least being to identify talent -- or for industry associations to take advantage of 'public good' capabilities to access unique federal skills (e.g, the Fisheries R&D Corporation's use of CSIRO for fisheries and environmental information). It's quite another, however, to ask industry to invest in its main line product development in a government lab, particularly when that lab has no real sense of urgency, as well as its own view of the world. I realize that CSIRO is chartered to help industry, and that what I have just said perverts this noble cause. However the reality, from what I observed, is much along the lines I have described. CSIRO labs view industry as their paying customers, and seek funds from them to conduct their business and build their own capacity. Since this section is about sponsors and mechanisms, I'll simply say it's not at all clear to me that this element of the 'innovation system' serves as an effective instrument for inducing private investment in productive innovation.

Performers: I discuss in turn Universities; Government Labs & Research Centers with a focus on CSIRO, Defence, and Ocean Sciences; CRCs; and Industry. Some of these of course are also sponsors, but their characteristics and the issues differ in the two roles.

Universities: The public University system has been shaped over the last decade or so by three major forces. One is the recent press for innovation and commercialization, which interestingly is

at least in part a by-product of the very effective work ARC and others have done in convincing the federal government that investment in science and technology is an essential ingredient of economic growth. Once this point was grasped they seem to have taken it on with a vengeance, and view the university system[226] as the nation's factory for skilled workers and industrial researchers, as well as the repository of valuable IP that when commercialized will transform the economy. The second major force was the Dawkins reforms (I think I have the name right...) of the early 90's. While I haven't studied the details, the effect was to roll up a large number of colleges and polytechnics into Universities through a process of amalgamation and name change[227]. As a result many of the larger universities now have several campuses, 'elitism' is discouraged in favor of leveling (with associated impacts on standards and prerequisites...it's hard to tell how much of the impact has been real as opposed to perceived), every institution feels it has to get into the research game (with the inevitable impact on costs and faculty perceptions, promotion, mobility, etc[228]), and DETYA runs a 'one size fits all' higher education operating block grant scheme that, while supposedly tailored for individual institutions through the Educational Profiles, has to stretch its basic constructs across a very broad complex of institutional quality and purpose. The third is implicit in the second, namely that in spite of the protestations of the bureaucrats, Australia's higher education system is quite tightly regulated; albeit, interestingly enough, with no clear strategy in mind beyond the basic philosophy of letting each University name its own poison, and letting the students choose their own route (to a more limited degree than the rhetoric makes apparent, in my opinion).

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[226]I am leaving out of my discussion two other elements of the higher education system: private providers (two private universities and a number of theological institutions); and the "registered training organizations", that include the "Technical and Further Education institutes and colleges (TAFEs), private training colleges, businesses that provide structured training, and community trainers such as adult and community education providers" (*The Good Universities Guide*, 2000 edition, "Going to a VET college"; VET=Vocational Education and Training). These are career and further-education oriented, reflect employer needs, provide nationally recognized certificates, and are HECS-exempt though they do charge fees (which however are only about $600/year for full time study at a TAFE institute compared to the $3-6K HECS). There are about 4900 of these organizations, and many offer distance education; they have over a million and a half students. While the VETs enhance skills and often serve as feeders for the Universities, and thus are a very important part of the innovation system, they play only a tiny direct role in S&T and research per se.

[227]The UK did much the same thing when its turned all of its polytechnic institutions into universities. I haven't seen any really good studies of the impact of these transformations, but have heard few commendatory comments, and lots of negative ones. As is clear from the text, my personal opinion is that such 'leveling' steps are counterproductive for at least a half a dozen strong reasons. However once done, there's no way to go back, so the issue is how to constrain costs, maintain quality as related to mission, promote excellence, reward diversity of expectation on the part of both faculty and students, and prevent needless redundancy and damaging competition. I don't get the feeling that Australia shares my opinion that it should even worry about such things.

[228]The academic ladder is also somewhat different than the US system, with a couple steps of lecturer, then associate professor, then professor, which is more tightly constrained than in our system, and typically goes with the head of a department or some other administrative unit. One similarity is that there is both a teaching and a research staff, with the latter depending on grants and contracts; and, more of a trend toward term appointments than the traditional tenure system. I didn't investigate these factors in any detail and they are probably not terribly significant for my primary intent, which is how to cost research from ONR's perspective. They do of course have a major influence on motivation, mobility, and the like. One very significant feature of the system is the relatively low pay. This is what makes the Federation Fellowships -- 5 years at about US $110-115K a year -- so relatively attractive. As noted above, however, one wonders what will happen in year 6; and here all of a sudden, the system has created 'two-level citizenship'. Will this huge differential for just a select few really be motivating? Or will those who applied but didn't quite make the cut now be further encouraged to emigrate?

Thus while the Universities each have their own personality, and there are both self-annointed and government determined groupings (e.g., the Group of Eight, the 5 who have recently formed the Australian Technology Network, the 13 Regional Universities), they share some common characteristics. First, most of them, at least most of the ones I visited, are quite large[229]. At the undergraduate level, they can be characterized as 'degree factories'. Part of this comes from the basic approach whereby a student enrolls in a selected course of study at the start, in a baccalaureate program that is basically three years in length (with considerable variation, of course; law can be up to 5 years, medicine 6 including a year of practice, and there are a number of popular double-degree programs). Part comes from finances. To quote the *Good Universities Guide*[230], "universities and other tertiary institutions are not the happiest of places. There have been huge cutbacks in government funding in the past ten years[231]. That leads to big increases in student-staff ratio which leads to overworked, stressed-out staff". Part comes from motivation; to further quote the Guide, "The main purpose of education is to get educated, to get your qualification, to get ready for the next stage. But that's not the only purpose...Expand your mind...It is getting hard to think this way about the years at university. Time is a problem, especially if you work part time (which most students do). And study is getting so competitive, with people intent on getting jobs" (p2). Not once in my 6 weeks in the country did anyone talk about the joys of study, of learning to learn, of the relative freedom from worldly concerns that can come from a university environment, or of contemplation as a valued element of learning.

Another general stress is the impact of the formula-based grants schemes on different fields of study. To quote a September newspaper article, "By 2020 Australian Universities will be empty of chemistry, physics, math and engineering academics if present trends continue, a joint contingent of scientific institutions warned"[232]. Such concerns were expressed on campus

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[229]Monash University in Melbourne is a good, if extreme, example. It has almost 41K students, including 32K undergraduates, 36% with non English speaking background (6600 international undergraduate students). It has six campuses, and 10 Faculties, and also emphasizes distance education and flexible learning, including Open Learning Australia. It has a centre in London, and campuses or courses in Malaysia, Singapore, Hong Kong and South Africa. Plus it has innumerable deals and partnerships with businesses and other universities. And, it's second in the region on most counts to the University of Melbourne, its older and more prestigious neighbor, that itself has 33K students.

[230]*The Good Universities Guide to Universities, TAFE & Private Colleges in 2001,* 2000, Hobsons Australia PTY ltd. , and a similar guide *to Postgraduate and Career Upgrade Courses.* Designed to help students make smart choices about where to go and which course to take, these guides provide descriptions of each institution and its courses, as well as costs, entrance requirements, performance in the job market, etc, and ratings in a range of areas, from gender equality to research income. I found them to be extremely valuable for an introduction to the system, and indispensable in determining where I should visit.

[231]The Group of Eight web page, www.go8.edu.au, states that since 1996, government funding for general operating purposes has been cut by 6% in real terms; government university funding was 0.72% of GDP in 1995, projected to have dropped to 0.52% by 2003-4

[232]"Industry and academics warn of a future where science is fiction", Cynthia Banham, Sydmney Morning Herald (smh.com.au), 21 September 2001. To continue the quote, "physics departments have seen a fall of 29 percent in academic staff and 18 per cent in students since 1994; the number of academics in mathematics departments have fallen by 30 per cent since 1995; and academics in chemistry departments have decreased by 27 per cent since 1990". The article goes on to say that the Minister of education said the concerns were unfounded, but "eminent academics and businessmen contradicted him"...perhaps this comes from a reasonable defense of the system by the politician in charge, but more likely, per my discussions on campuses, a serious difference in perception between the bureaucrats in DETYA and the universities themselves. Of course, the hard sciences aren't necessarily the only ones hurting. The Group of Eight reports that student:staff ratios for the humanities have gone from 15.5:1 to 20.1:1 since 1995; here however, I'd expect that it's more due to increasing student load and overall reduced funding of higher education, rather than a major staff loss.

after campus that I visited. Physics and math in particular have taken hits, and some universities have shut down their physics departments altogether. While I may be too simplistic in ascribing the problem to a single root cause, the stress on the fields of basic knowledge that underpin the new technologies in undeniable. And, when the Universities are rewarded based on student load, and the students are pressured to look at the short term aspects of education in terms of immediately marketable job skills, and the universities basically pass the rewards and penalties on to their Faculties and Schools, you end up with a system that can get caught in a self-fulfilling spiral. The system is essentially strategy-less and formulaic based, so the fact that such unintended (at least I assume they're unintended) consequences occur should not be a surprise. At issue is what if anything the policy makers, bureaucracies, and universities themselves, will do about it, if anything. The Group of Eight web site (www.go8.edu.au) contains some interesting comments in this regard. Apparently I'm not the only one who thinks the system is out of whack.

Money also drives in another way. DETYA's *Higher Education Report for the 2001-2003 Triennium* shows that in 1999, university income came 65% from Commonwealth grants and HECS, 9% from overseas student fees, 2% PG fees, 7% other fees and charges, 3% investment, 7% other grants and contracts, and 7% other. In 2001, international students (from 207 countries) were up 200% from 1995; by 2003, they estimate that student poputation will have increased 27% from 1995, with domestic students accounting for 11%. Particularly for the major schools, and most particularly for those in desirable areas (like the sunshine coast or some of the big cities), international education is a very big business. As I was told in Queensland, it brings in some $4B a year, more than wheat exports[233]. Higher education, then, is viewed very much as a marketable commodity. I'd imagine this has an interesting impact on the nature and quality of teaching, especially in a time of declining government funding and other systemic stress.

On the graduate and research side, where I focused most of my attention, the emphasis is very clearly in line with government policy: commercialize, commercialize. Interestingly, Australia accepts as a premise for its press toward commercialization, that it has excellent basic science; one frequently used statistic is that the country produces 2.5% of the world's knowledge, well above what should be expected for its numbers -- it punches above its weight. What one doesn't hear a lot about is what fields this knowledge is in, or how the knowledge productivity relates to the most popular and rightly rewarded fields, or how either relate to industrial potential. Australia has a good reputation and publication record, for example, in mathematics, astronomy, and physics. On the same score card, it's poor in information technologies. One might ask if while compensating for intellectual weakness (e.g., the COE in ICT) it might want simultaneously to avoid compromising strength. And in general, one wonders if the funding levels for higher education, the formulaic reward system, the treatment of education as training (including PhD education as "research training"), and the lack of rhetoric at senior policy levels about the real fundamental importance of retaining the basics above all else[234], are truly conducive to underpinning excellence in disciplines of fundamental importance for almost any conceivable future economic environment.

As with other aspects of the system, in research and its exploitation there are both commonalities among the Universities, and quite different approaches. All of the universities are identifying niche areas for focus (indeed they have to name 10 areas of excellence as part of their Educational Profile). All of them are emphasizing cross-disciplinary skills and collaborations. All of them use Centres or other focusing techniques to build critical mass -- there are Centres

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[233]The Group of Eight web site puts the figure at $3.7B, more than exports of wool, beef and veal, alumina and aluminum. Take your pick...it's still big and important.

[234]Yes, all the documents start with statements about excellence and the importance of basic research. But then they go on to ignore them. It's as if it's sort of assumed that they don't need to do anything to ensure they prosper. My point is simply that I'm not at all convinced that such benign neglect will prove adequate, when all the incentives are in other directions.

(and generally reasonable rules for their establishment) at the Department, School, and Faculty level, as well as ARC-supported National Key and Special Centres, and the AusIndustry CRCs. Confusing, actually, in trying to figure out just what sort and magnitude of a 'centre' you're dealing with, but the implication is clear: build strength through multi-disciplinary collaboration in clearly identified niche areas. And, they are all focused on industry; income from and collaboration with established industry, and the creation of industry through spin-offs and start-ups, or other applications of their IP.

All the universities are very IP conscious, albeit they have different ways of dealing with it[235]. Some have their own industrial parks and incubators, others have companies which operate parts of their facilities commercially, some have close proprietary arrangements or joint ventures with industries for purely commercial endeavours. All (that I visited) are part of CRCs. There are actually very few commercial things they can't do, including -- as best I can tell -- taking full ownership or significant equity interest in commercial enterprises. Some of the *BAA* and *K&I* initiatives even encourage venture-capitalist behaviour by the public institutions. Great, I suppose, but there's not unnaturally a range of business acumen in how they evaluate and approach opportunities, and one wonders what might happen in the event of a huge loss or a major law suit. Maybe the protections are there, but they sure weren't immediately apparent. Will the government ultimately accept liability, or will it let a major university go down the tubes? What if majority ownership in a BT company in which a university has a 30% equity stake is acquired by Iraq, directly or through cut outs? Are there businesses in which a University should not invest, for reasons of ethics or conflict of interest (e.g., production of texts for secondary schools, or recruiting movies for the military of a foreign country, or bioprospecting for a European pharmaceutical firm?)? Have such questions even been asked? Should they be?

On the other hand, from the standpoint of an external buyer of research, the Universities are a very good deal. Overhead, infrastructure, and academic staff salaries are paid by the Commonwealth, so compared to the US, research is cheap. Further, salaries are low in absolute terms, and the exchange rate is good. Quality is high, as is productivity. The scientists and engineers as well as the students are for the most part very bright and motivated, and truly interested in not only their research but its benefit to society. The Universities themselves, as well as the states and federal government, encourage external investment, and no one I met evinced any aversion to working for a 'military' organization like ONR. Indeed, national security seems to be accepted as a perfectly legitimate avenue of intellectual endeavour on all the campuses I visited, and there are many defense industry sponsors who are making very good use of the talent. None of my seeming criticisms therefore should be taken to imply that Australian universities are anything other than an excellent source of talent for ONR's (or industry's) immediate research interests. My concern is simply how long this goose can continue to produce golden eggs, thus the wisdom of long term commitments. At some point, given the rush to commercialization, the Universities are going to run out of their previously accumulated stock of ideas and talent; at issue is whether the system will adequately refresh them.

Government Labs and Research Centers: This is a decidedly mixed bag. First, there are some stellar examples of world class expertise. BMRC and parts of DSTO have world leading capabilities. AIMS is world famous for its tropical marine and coral reef research. CSIRO receives very high rankings for the quality of the science in many of its divisions. However there are some systemic concerns, perhaps the largest being the labs' role in the nation, and -- as at universities -- the 'one size fits all' approach to funding the labs in CSIRO. Indeed CSIRO is of particular interest simply because of its size and breadth; with 21 divisions, it is as some say a

[235]Melbourne, e.g., gives the rights to their faculty, while most keep it at the university level or assign it to a university owned company, and have a sharing arrangement -- typically 1/3 each -- with inventor and Department. There is also a wide range of expertise in IP management.

mile wide and an inch deep; or, rather like a big university without students. I'll therefore start with some comments about it, then discuss defence and ocean science, areas of particular concern to ONR.

CSIRO: Nobody involved in Australian S&T ignores CSIRO. In the first place, that's physically impossible because it's everywhere. It's in almost all the CRCs, has relationships with most all of the universities and a physical presence on or near many of the campuses, is in all the States and territories, and with very few exceptions touches almost all aspects of science, technology, and engineering -- everything but the humanities and creative arts. For many Ministries, it is their only source of government laboratory support. Even BOM and DOD, with their own excellent labs, rely on it in some areas. And as said before, few would argue about the quality of much of its research. At issue, therefore, is who does it serve, and how well?[236]

I've already noted that although by charter CSIRO is supposed to support industry, there's a bit of an anomoly in a free market system when government expects industry to pay it to do what industry would likely rather do itself[237]. Further, CSIRO generally has a poor reputation (earned or not) for its management of IP, both from the standpoint of sharing samples and data with universities, and for inept commercial exploitation. CSIRO is often seen as a competitor (to universities as well as industry) rather than a supporter. Some would even say that CSIRO is the worst thing that ever happened to Australian industry. It moved the taxpayers' investment and the incentives in the wrong direction, replacing market oriented commercial R&D with government research, creating both implicit and explicit public-private competition[238], impeding the development and effective exploitation of IP, and now trying to commercialize through technology push, which is doomed to failure[239]. This may be overly harsh, but there is certainly something to be said about the wisdom of expecting government, in a free market based global system, to spark economic growth principally through investment in its internal technological capacity, particularly when there is no program to pay industry to perform R&D to provide the systems and capabilities needed by the government. The US may not be perfect in this regard, but its SMEs are widely known as engines of growth and innovation, and Australia seems to have turned our system on its head.

A second rationale for government labs is to help the government do its business. This is always a tough line to draw, and has occasioned endless arguments in the states, because the

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[236]I may not be alone in asking such questions. One of the most interesting points about *BAA*, in fact, is that in spite of its largess to universities, CRCs, ARC, industry, etc., CSIRO was notably left out. This could not have been an inadvertent oversight.

[237]SMEs are a particular concern, given their potential impact on innovation. As viewed by at least one CSIRO lab director, SMEs are the clients from hell. New Zealand has much the same problem with its CRIs and small businesses (see Report 11): many SMEs don't understand research, couldn't uptake its output if it was given to them, and in any event don't have the money to pay for it, especially when the tax concessions make it desirable to do any R&D, if the need and capacity exist, in house. And for those SMEs that I visited, that basically survive by their technological wits in a hotly competitive global market, turning product-related skill development, or new idea development over to a government institution, would be anathema.

[238]Several of the projects I saw were directly, and apparently intentionally, competitive with ones being done by universities with and for industry. If, for example, the government lab was doing its work to help the government make smart-buyer decisions, or to enlighten regulatory development, etc, this may be understandable. But no, it was pure, knowledgeable, deliberate commercial competitiveness that inspired the work, abetted by government access to information and funding. This is supposed to help?

[239]Technology transfer and commercialization are not perfected arts by any measure. However there is a school of thought that is supported by considerable evidence, and that is reflected in this comment, that says market pull is much more likely, for a whole range of reasons, to succeed than is technology push. Australia's approach, in particular CSIRO's is very heavily biased toward tech push. Sell what you've got.

nature of that work changes, and the capacity to perform the work can't be precisely defined, leaving either holes or, perhaps worse, excess capability that has to find a way to both feed itself and feel like it's doing a worthy job. But basically, any 'mission agency' needs knowledge and tools to do its job, it wants these when and in the manner in which it needs them, and the information must be free of conflict, especially financial. So the government needs either to do the work itself, or to hire skilled honest brokers to do it for it. In many sectors, such 'public good' research and data collection is done in Australia by CSIRO labs. At issue here, is whether it is better to have a central organization supplying many ministries, or to let each Department manage its own capabilities, tempered by fiscal constraints and their ability to argue their case to the purse holders. Either can work of course, and to an extent Australia uses both approaches, witness BMRC and DSTO; but it is not at all clear what role, if any, the various Ministries now play in determining what capabilities CSIRO should have, or whether CSIRO is meeting their needs. The very recent shift of the organization from the industrial to the science portfolio may lead to some interesting discussions on this point.

A third rationale for government labs is 'discovery' in areas that are either too sensitive or too expensive for any other organization to undertake. Nuclear weapons and the international space station are two immediate examples. CSIRO is called upon to perform some of these functions as well, e.g. for the Parkes Radio Telescope (recently the eponymous hero of the movie "The Dish").

This diversity of functions -- supporting industrial strength and commercialization, meeting government needs, and conducting large scale basic science, all of which and more CSIRO seems to be trying to perform -- must inevitably create internal conflicts. Further, irrespective of the nature of a CSIRO lab, public good or commercialization (I visited some of each), all seem be operating under a common imperative to raise a considerable portion of their support from 'customers'; at the same time, there is no customer, or at least no customer-supplier relationship, associated with their basic operating grants (they do of course have to work to an approved plan; but that's fundamentally different from something like the industrial funding or other pay-for-work approach). This gives them a good deal of internal freedom to determine their work program, but at the same time tightly leverages their capabilities and base expenditures to the interests of the external customers, who are in essence paying on the margin. Basically, there seems to be no clear separation between 'public good' functions and industrial or commercially oriented functions, either in terms of objective or approach to funding. I have to assume that there are different arrangements for some sites like Parkes; but basically what I saw was a one-size fits all approach to managerial procedures and financing, which exacerbates the problems caused by unclear mission and customer identity.

As with the universities, however, none of these concerns reduce in the least the value of CSIRO labs to external research sponsors like ONR. They can provide superb value for money, and are more than anxious to do work for pay. Nor are my comments meant to fault management, which seems under the new leadership to be struggling with many of the same issues that perplexed me.

DSTO: DSTO has some exceptionally strong traditional capabilities, as recognized in the Defence 2000 White Paper, in airframe and ship structures, and in aircraft life extension. Australia tends to operate their systems far longer than do we, so that this has become a matter of necessity that is also a point of due pride, and in which we often rely heavily on their expertise.

DSTO clearly does not suffer from the same 'identity' problem as do many of the CSIRO labs. If anything, under the WP, given the new responsibilities assigned to it, and the importance attached to S&T advice with regard to the upcoming systems acquisitions, its problems will be meeting the demand from a customer that quite clearly wants and needs its product. The

challenge will be to build capacity carefully, in areas that are complementary to those in the universities and industry, not to find an 'identity'.

As one who has had responsibility for the US DOD labs, there were several things that impressed me positively about DSTO's structure and programs. First, they are flexible and responsive. Second, most of their money comes directly to them, so that although the vast majority of their work is on directed projects, they have at least a modicum of independence and can state their case without fear of being 'punished' excessively by the sponsor[240]. The Services are able to buy additional support from DSTO, so this gives them as well a good degree of direct say in the organization's activities and control of its resources. The balance of authority is thus reasonable. Third, DSTO is allowed discretionary spending of a reasonable percentage of their funds (10%, increasing to 15%). Such flexibility is required to maintain intellectual strength and inspire new ideas; and most US defence labs would be very envious.

Much of the challenge over the next few years will be in defining the technical aspects of the 'replacement' systems being planned under Defence 2000. During this process, DSTO should also be expected to help DMO determine required indigenous strengths. These tasks will require upgraded ops analysis and M&S capabilities, which DSTO seems to be already working on. I was also pleased to note that at least one academic group (and its commercial spinoff) is developing procedures to simplify the development of M&S code that complies with the US-mandated HLA, which they will have to follow to integrate their 'virtual' world with ours; this an important goal for both sides, particularly given our increasingly close relationships in submarines (and soon, I'd expect, AAW). Overall, if the US is indeed seriously interested in making Australia a true "partner" in S&T, R&D, T&E, experimentation, strategy, and system acquisition, DSTO has taken many of the right steps to enable an easy technological and procedural fit. The fact that I kept running across Australians at every US lab and operational command (and many policy and program offices) I visited in preparation for my visits may have something to do with this. They understand us well, and it shows.

Another impressive point was that many of the advanced command and control techniques they are researching are based on very sound thinking about the fundamental principles underlying human decision making and complex systems; one may disagree with what they are doing, but they know why they are doing it, so if you want to argue, you have to start from the basic principles of physics, chemistry, and psychology. In several cases that I unintentionally tested later through questions at university presentations, especially with regard to the human or cognitive element -- becoming ever more important in a knowledge rich environment -- their approach seems to be supported well by rigorous academic investigation and up-to-date findings from basic research. This solid grounding is a great strength (and common to the best of the other labs, including e.g. BMRC), particularly for a mission oriented organization that does not itself spend a lot of time and effort on basic research in-house. I have consistently argued that common understanding based on fundamental principles is an essential underpinning of collaborative system development and interoperability; this is one main reason that ONR has an IFO. DSTO's approach should help us in that regard, since it provides a sound basis for a common approach to the development of future capabilities. The BMRC-NRL, Monterey collaboration is a good model of what we would like to achieve with DSTO, and it works well because of common views of nature and common fundamental approaches.

My one concern, to reiterate much of what I said in the sponsorship section, is the degree to which DSTO (and its DOD leadership) calls upon industry and academia for

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[240]This at times has led to divergence of views with the Chiefs of Service, but in the case of Navy at least such disparities seem at the moment to be minimized, and the Navy Science Board would appear to be an appropriate mechanism in which to discuss differences of opinion without disrupting progress. The most recent reorganization should help even more, since it seems to further clarify the customer-supplier relationships between parts of DSTO and parts of the DOD and the Services.

innovation. DSTO is respected as a 'good sponsor', participates in many CRCs, works well with the universities, and subcontracts to industry. At issue however is the degree to which it sends out 'capability requirements' or broad project concepts against which others can propose their own approaches, as opposed to requesting bids for specific developments in line with its own constructs. Certainly a lot of the latter is needed, to complement in-house talent and attack problems for which the proposed solutions are well defined (this is part of being a good performer). But if innovation is the name of the game, and Australia truly wants to inspire defence industrial participation in the global stream of military ideas and products, then it needs to do a whole lot more to actually pay up front for novel developments and ideas, and encourage (fund) SMEs in particular to advance their own ideas and technologies. This is not a fault with DSTO per se, but rather a concern that nowhere in the Australian system -- Defence or civil -- does there seem to be a mechanism (like the OXRs, or the US SBIR programs) that is deliberately designed to encourage industry and academia to proffer their own ideas to meet government needs.

Ocean Science: Marine issues fall under so many jurisdictions at Federal, State and local levels, and influence so many aspects of a nation's activities, that rationalizing the government's role is always difficult[241], particularly since ocean science is capital intensive and expensive. Interagency committees of one sort or another are essential, and in Australia HOMA seems to attempt to play that role on the performer side[242], although it is not clear how effective it can be, or how well the States and Territories are involved in its activities. What does seem clear, however, is that whether deliberately or not, Australia has not elected to make marine science and commerce an issue of major national concern.

There was an attempt, a very few years ago, to deal with ocean issues through the National Oceans Policy and Office, and the associated Marine S&T Plan. However the total resources allocated to the combined recommendations of these documents was $50M, just enough to get started on developing the Regional Marine Plans; and even those beg the issue of integrating coastal activities with those further offshore. In the meantime, perhaps because the diversity of issues is so great and the number of possible actions so bewilderingly large (e.g., the Plan's 29 objectives, each with multiple priorities and strategies), that resources remain dispersed and little coherent progress is being made. Even in an area of acknowledged mutual interest among all concerned, data, there remain open issues such as the relationship between the HOMA committee's efforts, Navy's AODC, BOM's observational networks, and the states' coastal programs; exacerbating the data management problem, there is a paucity of offshore moorings and similar long term observing systems, and no apparent coherent plan to participate on a national level in major international programs like GOOS, except for the provision of a few ARGO floats (and perhaps an initiative of WA).

Perhaps the most significant deficiency is in ships. AIMS operates a couple of trawler-size vessels, CSIRO's CMR is selling the national research vessel *Franklin* to be able to upgrade and operate the more capable *Southern Surveyor* half time as a national ship, some of the universities have a variety of nearshore craft, and AGSO (Geoscience Australia) and the Antarctic Division lease support or use the one national ship. Navy has two hydrographic ships, but from what I understand their status also is problematic; and with the exception of some work in acoustics, DSTO does little if any marine science and has no seagoing ocean research capability. Basically, what this means is that Australia, for all its maritime size, has one major ocean going

[241]The US has recently established an Oceans Commission to look at such issues.

[242]NOMB and its advisory panel should be doing it on the sponsor and policy side; notably, there is no defence or foreign affairs presence on either

fisheries and oceanographic research ship, which will operate about 180 days a year. This is one of the few areas where New Zealand's research capabilities are the envy of their larger neighbor.

Ocean science expertise is likewise dispersed. Several universities have ocean scientists or engineers, but they are generally few in number and dispersed. There are however a few very capable Centres, e.g. at Curtin in Perth and James Cook in Townsville. BMRC has considerable modeling expertise (and leads the international GODAE program), but except for the (not yet finally approved) Ocean Modeling and Analysis Program, its efforts do not appear well integrated with other efforts in either the country or the Asia-Pacific region. The one oceanic CRC, dealing with Antarctica and the Southern Ocean, will likely not be renewed, and the Southern Hemisphere Meteorology CRC (like the Maritime Engineering CRC) has already disappeared. AIMS, headquartered in Townsville, and CSIRO's Marine Research Division in Hobart, both have excellent capabilities and research programs, but again their efforts are not closely integrated (e.g., both are increasing their presence in Western Australia, but not, the best I can tell, in a coordinated fashion), and the Chief Scientist's recent report recommends that these two government labs remain separate.

Overall then, ocean science is an area where Australia has some very strong niche expertise, a thin but broad covering of all the relevant fields, and a woefully inadequate infrastructure. Given the strategic importance of the maritime approaches, the projected changes to the Navy under Defence 2000, the marine resource GDP contribution and potential, the size of the EEZ, the political and economic significance of the ECS under UNCLOS, Australia's commitments to and interests in its island neighbors, and the ecological importance both locally and globally of its unique marine environment, I can't help but wonder why Australia can't seem to get its act together better in this area.

CRCs: CRCs are a very bright spot in the matrix of Australian innovation mechanisms. As a device for effectively meeting the needs, and combining the talents, of all three sectors of the S&T community -- government, academia, and industry -- they have left CSIRO in the shade, to quote one of my hosts. Of the technologically oriented CRCs that I visited, virtually all had extremely strong research capabilities, were producing valuable results for their participants, had coherent business plans for the future, and were entrepreneurial in their approach to responding to 'market pull'. From what I could tell both their staffs and their students (research trainees) were very highly qualified and motivated, not least perhaps because of the competitive process required to form a CRC. The effects of the CRC process reminded me very much of those of the Framework Programme in the EC; they have induced effective collaboration among strong centers and individuals that otherwise would never have coalesced. And, because they are essentially project oriented, even if the participants disperse at the end of their funded period they will have created contacts and synergy that otherwise would not have occurred.

The CRCs of course are not all equal, and themselves have been subject to a certain amount of criticism. The participants do need to share the resulting IP, or vest it in the enterprise, and this can work to the disadvantage of an individual organization if the contributions of the partners are not reasonably well balanced. Managing a dispersed coalition is not easy, and if not well done can lead to a CRC degenerating into a pot of funds over which the participants squabble. Not all have been as successful as hoped in commercializing their results, and some are quite narrowly proscribed around one of two extant industries. And, requiring a much heavier industrial contribution may drive away desirable participants. But by and large, over its slightly more than 10 years of existence the program has provided exceptional leverage and ROI to all its participants, in the form of new knowledge, new talent, greater connectivity, new products, and a modicum of commercial success.

Perhaps my major concern, which I have expressed with respect to other Australian programs, is the one-size-fits-all rules. While there is an admitted economic component to almost

any activity, it is somehow hard, it seems to me, to squeeze conservation and management of marsupials under the exact same rubric as cast metals manufacturing. The program objectives are quite clear in that the outcomes of a CRC have to be of benefit to Australia, and such certainly pertains to the examples I'd cited. However there is, under government innovation policy, a clear bias toward industrial development and commercialization as the type of benefit that is most desired. Yet at the same time there is clear value in using the CRC construct of multiple-party cooperation, to advance knowledge and capability in purely (or at least initially, given the status of research -- say, artificial photosynthesis, where there might ultimately be lots of commercial potential) public good arenas; or, for example, in an area that will be of primary benefit to government as the only or primary customer, say in advanced radar systems or energetic materials; or where the value is so broad that it can not be appropriated by any one industry or sector, e.g. control of invasive species. The rules of the game, the nature of international participation, the selection process, and the nature and objectives of the resulting consortia, may all be somewhat different in such 'public good' cases, than in the more clearly commercial ones. If nothing else, the time frames and nature of economic benefit are quite different, so expectations should likewise be different. I recognize that to date the program has managed quite successfully to cover the spectrum, and there is wording to try to cover the cases where there is promise but not yet an industrial base; but in listening to the comments of many researchers in all three sectors who were contemplating bids for the 2002 round, I sensed that a number of excellent ideas may not get proposed, given the magnitude of the effort needed to develop a good proposal compared to the expectations of what's really wanted.

Overall, however, CRCs have performed very well, and even when they haven't met expectations, they have at least identified weaknesses in approaches or capabilities that can be otherwise remedied, if there arises a need so to do. This type of program has significant expansion potential, particularly if there is clear enunciation of different expectations for different types, and maturity, of the associated research and education. Emphasis upon SME participation in the next round, vice expecting the CRCs to simply make new SMEs, will present some interesting challenges, as well as opportunities. I saw one or two cases where an SME had benefited significantly from its participation in a CRC, even in the midst of, and perhaps even more than, some 'partner' industrial giants. I was also impressed that if an industry takes a long term view and itself plays a significant role in the formulation of a CRC, it can truly maximize its ROI through both people and ideas, not just immediate products. As my report recommendations made clear, I consider CRCs to present an exceptional opportunity for ONR participation, and there already are several that have projects of significant interest to us. It is also noteworthy that other sponsors, including DSTO and DHS, have caught on to the concept, and are in the process of forming their own "Centres" to meet their needs for research support.

Industry: The most notable fact of Australian industry's R&D is its very small size, in both absolute terms and relative to the government’s contribution. Perhaps this has to do with the small manufacturing base and market size in the country, plus the fact that many of the dominant industries are international, with their own significant research capabilities elsewhere. My trip through 11 countries in the Asia-Pacific region also indicated that Australia is by no means alone in attempting to boost S&T for the sake of economic growth, so the competition is pretty tough. On the other hand, the only large international company that I visited has quite clearly made a significant R&D investment in Australia, is investing more, and seems quite happy with the result. They started this investment as part of an offset, but have stayed because of the quality and ROI. As Australia embarks on its new defence industrial strategy associated with Defence 2000 acquisitions, it may pay to better understand and apply the lessons learned from this case.

I did visit a number of start-up companies associated with universities, and several SMEs that are involved directly or peripherally in the defence sector. Two impressions stood out.

The first is that the tax concessions and other incentives from a combination of AusIndustry, the States, and the parent universities, are extremely helpful. Where there is a commercial market, these Australian companies have been able to successfully penetrate and grow international demand through their successful competitive performance. Their products are innovative, high quality, reliable, and reasonably priced. Although in a small way and largely in-house, they continue to pour profits back into product improvement.

The second is that it's a bit of a different story when the government, in particular DOD, is the targeted customer. As the WP notes, Australia can not afford to build its own unique major platforms, so it acquires offshore. Typically of course, the seller whether it be a foreign government (e.g., US FMS) or international company, wants to sell an integrated end item rather than just the structural pieces. So it's hard for an Australian company to market its systems to its own military, except perhaps for peripheral items, or for upgrades; as well as a natural tendency for Australia to look to the big weapon system manufacturers, rather than their indigenous industry, for the leading edge technologies. Thus the complaint that they have to sell to the US (or UK, etc) first, before their own people will listen. A parallel concern (already addressed above) is that they are frequently constrained by the 'DSTO solution', rather than being able to offer their own innovations, except for a very constrained program of product testing within identified projects.

The only way out of this box, as far as I can see, is through a program of vigorous investment by the government in industrial R&D, especially in SMEs, starting very early in the process. I recognize that this is a parochial view, but it has worked for us, and has led to commercial spin-offs as well as enhanced industrial development in its own products, thus ultimately to better industrially-funded products for the government to buy. The fundamental premise here is that the government and commercial market places are drastically different; the Defence Minister clearly recognized this in his June 2001 speech that I have quoted before[243], when he stared clearly that the DOD "is a monopoly. We cannot pretend that the Department of Defence is a neutral player in the marketplace. It is the marketplace.". I'm simply arguing that for Australian Defence industry to develop and flourish, this construct needs to be applied to S&T as well as acquisition, and in particular to the nurturing of SMEs. The international primes won't do this, so the government can't afford to put all of its attention on the first tier if it wants its indigenous strength to become "part of the global supply chain for multinational defence projects". The same basic argument of course could apply to other sectors; the government seems, however, to prefer to fund itself.

Comments

Anyone who has read through this (excessively long) document will note that while I started with a rather straightforward description of policies and programmes, in discussing sponsors and in particular performers I have ventured more opinions. Largely this is because it is in the sponsors' relationship to the performers, and the performers' resulting abilities and opportunities, that the effects of the policies and practices are felt. And it's only by trying to understand and analyze those effects, that one can judge whether the policies are creating an environment that is conducive to the sort of cooperation between Australia innovators and my own organization that we envision we may want.

First, as I said in all three of my previous reports about Australia, from the perspective of ONR or any other outside 'purchaser' of S&T, Australia currently offers high quality at bargain prices. Modern infrastructure, high quality staff and students, and close connectivities with US and

[243]Op cit 17/190

European colleagues combine with a good exchange ratio and low basic costs due to Australian government subsidies, to create a buyer's market. There is also a good breadth of technical capabilities, particularly in areas of interest to ONR; and the centres of expertise are quite easy to identify, either by ourselves or with the help of DSTO and consultants. So in terms of simply treating Australia as a place to buy bits and parts of contract research, the answer is easy and everything is positive.

Part of the intent of this paper however has been to try to assess where the Australian system is going, so that as we evaluate long term strategies for engagement of a more fully cooperative nature we are aware of problems that may arise. That means making judgements about what's good and bad in the Australian innovation system, and -- even from the viewpoint of someone who has just taken a quick if reasonably intensive look its various parts -- trying to understand what might be done to make it better, or conversely what might cause problems. This is important, though perhaps impertinent, because if our Navy is to work much more closely in the future with Australia first in submarine R&D -- a matter of great sensitivity and importance to the US -- and then in other naval technologies, we must consider new forms of defence cooperation, including truly joint development, where we will be relying upon our colleagues in ways we have not previously done. We need therefore to try to understand the Australian system as well as we understand our own, even with all the hazards of misjudgments.

From that perspective, then, I can start by saying that I believe that there are some obvious complementarities between the Australian and US systems, different in detail and style though they may be. Australia's legal and regulatory environment, although I haven't dwelt upon them, seem compatible with our own. Same with fundamental values and ethics, and associated personnel systems. Our people work well with each other. There would appear to be adequate protection for IP and other sensitive information, and exports, upon which we should be able to base open and broad discussions of releasability. Should these basics not pertain, there would be no reason to go further. Also, Australia's tax and other incentives for industry would appear to be adequate to attract enough US commercial interest, including from SMEs, in starting Australian branches, to balance the establishment of Australian companies' US subsidiaries, should we want to truly encourage joint development of new systems which both of us would use and that could also play an appropriate role in the global supply chain. That is, there could be industrial equity at multiple tiers, that would benefit both sides. If we do seriously decide to do something new my views will of course be tested by intensive studies and discussions by the business, legal, and policy experts; but from my years of experience in Europe and in US S&T, I can see nothing that would inherently prohibit taking an innovative approach to intensive bilateral collaboration.

With more particular regard to the comparative strengths of the Australian innovation system, they seem better than we at building critical mass. The CRCs, university Centres at all levels, the new COEs, DSTO's new Centres, etc., all are focused at bringing the nation's best together to speed progress. We do some of this, but perhaps because of size and resources, tend still to have a lot of redundancy and dispersion of capability; witness the separateness and competitiveness of our three military services' R&D systems. On the other hand, the very diversity of US sponsorship has its own strengths. In Australia, essentially there's only ARC. A proposal that fails there, fails. It the US, between NSF, the OXRs, DARPA, NASA, etc., each with its own approach and criteria, there's a much broader spectrum of opportunity, and a much greater willingness to take risks. With only one place to turn to, and one set of rules, willingness to work outside the box is inherently constrained. And, as I have stated several times in this report, I consider one very significant weakness of the Australian innovation system to be that there is nowhere industry can go for federal R&D funding support to put forward their own ideas and

enhance their own capacity meet government's needs. ARC doesn't do this, indeed nobody does. There is no DARPA, there are no OXRs; there is no government 'market pull', only government technology push. This is particularly debilitating to defence (and other government function) related SMEs, and would create an inequity that would have to be considered in devising a truly joint long term collaborative development program.

Another concern in working with Australia in S&T is the degree of government control over the elements of innovation. Universities are federally funded. CSIRO is federally funded. The management may be benign, but at heart it's a state system, and thus a change in the government can have huge and immediate consequences. In addition to the problems that this creates for innovation in Australia for its own sake -- CSIRO as a substitute for and thus depressant of industrial R&D is a central example -- it inevitably will cause some concern in defining the nature of bilateral collaboration. It's not a matter of government ownership of industry that's the issue here; with the sale of ASC, that need not be a continuing problem. Rather, it's that the government has its hands deeply into the entrails of the innovation system, to the degree that industrial entrepreneurship is disincentivized at the same time that the government is trying to build it up; and indeed the whole system is therefore both politicized, and bureaucratized. Independence of ARC was a good first step, but there's a lot more deregulation, or decontrol, of the system that is needed in my opinion; as well as an investment policy that puts the taxpayer's money where it will generate economic return and yet more tax revenue, rather than into the government's innovation capacity itself. I'd suggest there are some in Australian universities and industry that might agree with this sentiment[244].

Another concern along the same line is that much of the 'regulation' seems to be without a cause, in the sense that there's no fundamental strategy guiding the investments. CSIRO, to pick on that target again, is all over the map and knows it; are all its 21 divisions equally important? Can't some of them just go away? If so, should it do public good S&T, or focus on business? If it doesn't do public good, who should? Are BMRC and DSTO better models? And if CSIRO does continue to do both, should they be treated like they're the same thing? What can industry do that CSIRO is now doing? If the country really wants and needs some of the industrial capabilities it is paying for, why not just pay for it in industry where it will generate true market place competition and economic growth?

Or:...on what basis does Australia decide how many tertiary students it should support? Is paying for 350K+ or so student slots anywhere near the right number, given Australia's need for higher education trained talent[245]? And in what areas should that government-funded education be? If the country is sufficiently serious about innovation to pay the bill for higher education, does it really make sense to let the system's content be driven in large measure by the choices of the 18 year old school leavers? Is it not a matter of concern that physics departments are degenerating and math is hurting? What impact is all the pressure for commercialization likely to have on basic skills and the nature of learning? Ditto for the emphasis on selling education overseas and bringing in fee paying foreign students on the structure and content of the

[244]I would like to believe that the questioning I am suggesting is more about pragmatic aspects of management and innovation, than about political philosophy. The essential issues to be addressed are, first, what government should do itself, and what it should leave to industry, given the objective of improving industrial investment in R&D and stimulating economic growth; and second but closely related, what are the criteria for and objectives of 'public good' S&T, and should such programmes -- if indeed it's decided that there really are such (certainly the term is used a lot in Australia) -- be separated in some sense from those designed specifically for commercialization and industrial growth?

[245]Compare, e.g., Hong Kong and Singapore -- see Reports 4 & 7 -- where one can argue with the numbers, but the government is quite clear about why it has limited tertiary education to the level it has.

Australian educational experience? Is training the same thing as education? If not, what constitutes the differences?

And...should ARC continue to simply respond to proposal pressure, or are there some 'strategic' directions of research that it might be important for the government to support in the national interest? And if not through ARC, then might there not be another mechanism to manage such 'initiatives' alongside some broad 'core'?

Lots of control with little strategy has its consequences. Is anyone really worrying about what those may be?

I realize that these sorts of concerns, and others like the one size fits all management approach behind many of the programmes including the stellar CRCs -- may be really more fitting for the Australian system itself to think about, than for an outsider. But again, if we're to change our approach to defence cooperation and seriously contemplate the sort of partnerships that are implicit in the RAN-USN Statement of Principles on submarine matters -- then such questions matter to us as well.

I'd guess that if I was to name the one concern that bothers me most, it's that to the degree that S&T strategy, policy, and process are important to a nation, then they are worthy of treatment as serious topics for academic research, inquiry, and debate on their own account. Yet I see no effort within Australian academia to independently study the impact of the nation's policy decisions -- and there have been a lot of them in the last few years -- or to subject the mechanisms of innovation governance and their effects, to rigorous scientific scrutiny. I simply think it's time for the Australian academic community, and its colleagues in industry, to start to ask a lot of hard questions in a systematic, scholarly way. Anyone care to propose this for a CRC?

Acronyms

AAW	Anti Air Warfare
ACT	Australian Capital Territory
AGSO	Australian Geophysical Survey Organization (now Geoscience Australia) *http://www.ga.gov.au*
AIMS	Australian Institute of Marine Science http://www.aims.gov.au
AMJ	Australian Maritime Jurisdiction
ANSTO	Australian Nuclear S&T Organization http://www.ansto.gov
AODC	Australian Oceanographic Data Center http://www.aodc.gov.au
APAI	Australian Postgraduate Awards in Industry
ASC	Australian Submarine Corporation
ASM	Anti Ship Missile
ARC	Australian Research Council http://www.arc.gov.au
B	Billion, 10e9
BAA	Backing Australia's Ability http://www.innovation.gov.au/ Real Results Real Jobs http://www.innovation.gov.au/iap/repport/200102.pdf
BT	Biotechnology
BMRC	Bureau of Meteorology Research Center http://www.bom.gov.au/bmrc
BOM	Bureau of Meteorology http://www.bom.gov.au
C3	Command, Control and Communications
CEO	Chief Executive Officer
CMR	CSIRO Marine Research http://www.marine.csiro.au
COE	Center of Excellence
COMET	Commercializing Emerging Technologies
CSIRO	Commonwealth Scientific and Industrial Research Organization http://www.csiro.gov.au
DARPA	Defense Advanced Research Projects Agency

DEST	Department of Education, Science and Training http://www.dest.gov.au
DETYA	Department of Education, Training and Youth Affairs, DEST as of 11/26/01 http://www.deet.gov.au
DHS	Defence Health Service
DISR	Department of Industry, Science and Resources, DITR as of 11/26/01 http://www.dist.gov.au/industry/research
DITR	Department of Industry, Tourism and Resources http://www.dist.gov.au/home.html
DMO	Defence Material Organization http://www.dmo.defence.gov.au
DOD	Department of Defence http://www.defence.gov.au
DSTO	Defence Science and Technology Organization http://www.dsto.defence.gov.au
ECS	Extended Continental Shelf
EEZ	Exclusive Economic Zone
FMS	Foreign Military Sales
GDP	Gross Domestic Product
GODAE	Global Ocean Date Assimilation Experiment http://www.bom.gov.au/bmrc/ocean/GODAE
HECS	Higher Education Compensation Scheme
HED	Higher Education Division (of DETYA/DEST) http://www.deetya.gov.au/highed/index1.html
ICT	Information and Communications Technology
IP	Intellectual Property
IPR	Intellectual Property Rights
IT	Information Technology
JORN	Jindalee Operational Radar Network
K	Thousand, 10e3
K&I	Knowledge and Innovation http://www.deetya.gov.au/highered/whitepaper
LME	Large Marine Ecosystem
M	Million, 10e6
MNRF	Major National Research Facility
NASA	National Aeronautics and Space Administration
NHMRC	National Health and Medical Research Council http://www.health.gov.au/nhmrc
NOMB	National Oceans Ministerial Board http://www.oceans.gov.au
NSF	National Science Foundation
NSW	New South Wales
OECD	Organization for Economic Cooperation and Development
ONR	Office of Naval Research
OTH	Over the Horizon (Radar)
OXR	shorthand for ONR, Army Research Office, and Air Force Office of R&D
PB	Patrol Boat
PM	Prime Minister
QA	Quality Assurance
RAN	Royal Australian Navy
R&D	Research and Development
RMA	Revolution in Military Affairs
SBIR	Small Business Innovative Research
SKA	Square Kilometer Array
SME	Small or Medium Enterprise
S&T	Science and Technology
T&E	Test and Evaluation
TTCP	The Technology Cooperation Program http://www.dtic.insts/ttcp.htm
UK	United Kingdom
UNCLOS	United Nations Convention on Law of the Sea
USN	United States Navy
VC	Vice Chancellor

WP	White Paper

Report 13: Assessments and Recommendations
5 December 2001
Introduction
Observations & a Few Comparisons
Country Comments and Recommendations
General Recommendations for ONR International Activities

Introduction

One of the few benefits of a trip like this is that it does provide a synoptic view of approaches to S&T -- which countries care, what are their policies and investment strategies, their strengths and weaknesses -- throughout an important sector of the world. My major concern in this regard is that I missed some of the most important players, and thus my picture of Asia-Pacific S&T is incomplete. Also, of course, my temporal and geographic coverage was spotty, I didn't examine all sectors, and I'm sure readers (and the countries and organizations I reported on) could find a whole lot of other flaws in my approach. Nonetheless, I believe that I saw enough to be able to draw some general conclusions, make a few comparisons, respond to the comments I heard at CINCPAC, and provide both country-specific and general programmatic recommendations to the Chief of Naval Research and other interested parties. I will do so in that order.

Observations & a Few Comparisons

The general observations are the most simplistic and least useful, but nonetheless set a baseline for what follows. First, no country completely ignores S&T in the modern world. All have individuals and institutions that have a lot to offer to others (such as ONR, which is a 'buyer' of research), even when measured on the tough scale of world-class quality. It goes without saying that with proper opportunity and education, every country has the human resources to excel in almost any field; the success of students from every country I visited at the best US and European universities attests to the basic equality of human intellect. Of course, opportunity, environment, culture and strategies do vary, and those are what make the difference.

For example, all 11 countries I visited would put IT and BT near the top of their list of S&T priorities (even if they rate S&T low on their overall list of priorities). Most of them would include materials and environment. These are common industrial, agricultural, and quality of life concerns, and promote fundamental capacities for societies that want to be part of the modern globalizing world. However what the various nations mean by the very same words can be drastically different. And, even more than I had expected, their approaches to meeting their objectives are highly diverse. There are very few commonalties in investment strategy, even when one groups nations into the sort of categories we normally think of, like 'developed' and 'underdeveloped'. Thus the greatest common factor, is difference; and not just difference in level of capability, but fundamental difference in intent, methodology, even philosophy. This is worth keeping in mind when trying, for example, to develop ONR's international strategy to support CINCPAC's objective of promoting multilateralism. It may be second nature to a diplomat, but not always to a scientist raised in the rationalist western tradition; the physics may be the same, but its relevance and uses are not.

In order to make any useful comparisons, then, let me start by very briefly synopsizing, from my reports and in the order in which I visited, each nation's approach to S&T policy and investment strategy as I understand it (however imperfectly, and in many cases now somewhat dated)[246]:

Japan clearly recognizes that broad world class S&T capability is absolutely critical to its economic future. As one of the world's leading industrial and technological nations, it -- like the US -- has nowhere else to turn if it wants to stay ahead. No more free ride. It has analyzed its deficiencies and taken major structural, political, and financial steps to try to overcome them.

Korea is maturing as a nation, and while still alert to the threat from the North is now focused outward, first trying to close the S&T gap with other developed countries then finding areas of regional, even global leadership. It understands that dominance even in areas of current strength such as shipbuilding, will require significantly improved indigenous technological capabilities. It is making reasonable investments and working to improve its weak management.

The **Philippines** understands that it must include information technology as one element of its infrastructure development, and appreciates the importance of biotechnology for agriculture. However its list of structural deficiencies and other problems is so long that doing more than maintaining a good educational system, and being aware of trends elsewhere, is not a priority.

Hong Kong is focused on business, banking, and transshipment, as well as urban development and a few other niche interests of its intellectual leaders. Although it has a good university infrastructure, it has neither clear priorities for S&T leadership, nor the ability to fund a critical mass in them.

Vietnam has a very sound appreciation for the need to increase its S&T abilities commensurate with the development of a modern industrial structure. It is making serious and carefully selected investments to improve its S&T infrastructure and capacity to support industrial growth, and to generate competitive entrepreneurialism in academia and industry.

Thailand does not view S&T as an important contributor to its future, albeit it knows it needs IT in order to be connected to the rest of the world and support the information needs of its foreign-dominated manufacturing enterprises.

Malaysia has placed a heavy bet upon IT in the broadest sense, although its investments to date have been more on physical than intellectual infrastructure. Until this bet pay off, it will focus on training 'knowledge workers' and improving manufacturing skills (automotive and aerospace) rather than advanced S&T.

Singapore has a well funded strategic list of S&T priorities that meets both its security and its economic interests, and a well equipped, well coordinated, tightly managed infrastructure to match. It clearly views S&T as critical to its future but is extremely global in its approach, with a minimal NIH factor combined with expertise in interpretation and integration.

India has a heritage of excellence in basic science that has been somewhat eroded by the 'black hole' of commercial software development; a poor record of application of its science in most

[246]I will have more to say later about how well I believe each is doing, to the degree it's relevant to ONR's own strategy; these comments are related to just whether or not a country cares and is taking any sort of coherent action.

fields; and a very long list of problems to solve, one of which is woefully inadequate infrastructure. Its S&T priorities are unclear, at least to me.

Australia is committed, through policy and funding, to commercialization of its very broad and capable government-centered S&T base. Its civil and defence S&T sectors are quite well connected. Recognizing that it missed out on the last round S&T commercialization, it intends not to miss the future payoff of ICT and BT, but otherwise has not clearly prioritized areas of investment.

New Zealand appreciates the importance of S&T, and has modern universities, but has not invested heavily and has no real S&T sectorial strategy beyond improving value added in its agricultural commodities and supporting a few small industrial clusters.

If then I was to group the countries on the basis of how much they seem to care about S&T and how carefully they have thought through their approach, the top category -- significant financial (relative to ability) and cultural investment, and well defined national strategy -- would have to include Japan, Singapore, Korea, Vietnam, and to a degree Australia[247]. Malaysia and Hong Kong would fall somewhere in the middle, in terms of having identified a couple of important sectors but not investing terribly heavily in advanced S&T per se. New Zealand (mildly concerned), India and the Philippines (too many other problems) and Thailand (doesn't seem to care) would make up the third category. A somewhat different way of looking at it would be to ask how seriously the nations treat the subject of S&T strategy and policy as itself worthy of intensive and scholarly analysis, and here Australia would drop out of the top category. Overall, I would give Japan, Vietnam, and Korea the highest marks, in terms of insightful assessment of their strengths and weaknesses as the basis for policies clearly designed to improve their position.

Another area where comparison is important to ONR's posture is the quality of research infrastructure. World-class research these days pretty much demands world class technology, from computers to sophisticated analyzers. Here Japan, Singapore, Australia, and Hong Kong stand out. Japan in particular has invested extremely heavily in technology for science, indeed well beyond its ability to fully use what it has[248] to its utmost scientific potential. Vietnam recognizes how important an issue this is -- a country can't expect its scientists and engineers to lead industry from behind -- thus its investment in "Key Laboratories". Korea also to a degree, although most of its infrastructural investment seems still directed to transportation and facilities, and IT (connections to the web). Malaysia also is investing heavily, if one counts the Multimedia Supercorridor; certainly it can't be discounted, even if as in Korea most of the money has gone into roads, buildings, and fiber optic connectivity. It is significant, of course, that these two countries place information infrastructure on a par with roads, rail and air. Modern 'goods' move in bits and bytes, as much as in trucks, trains and planes.

Also interesting is the degree of internationalism[249]. Japan and Korea lead, not surprisingly, in terms of overseas investment in the region, and Japan is way ahead in terms of welcoming scholars from other countries. Singapore is very internationally inclined, but more in terms of

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[247]See Report 12 for an in-depth critique of Australia's innovation system. I have been perhaps less generous to Australia here relative to the other nations than is warranted, because I spent so much more time trying to analyze its programme.

[248]The integration of STA and Monbusho is intended, in part, to rectify this deficiency. Given Japan's economic difficulties, it is unlikely that the extremely heavy investment in infrastructure can continue at the pace of the last decade, so the problem may be self-solving.

[249]Looked at here in the very restricted sense of S&T interaction among the countries I visited.

moving people to and from the west and buying things, than investing broadly in other regional nations' capacities. Australia's international interests seem largely limited to exporting education. Hong Kong hired many top quality international scientists for HKUST, but seems more interested in interacting with ethnic Chinese on the mainland and elsewhere, than with the other countries in the region. Most, of course, are competing -- with each other but even more with China -- for FDI, with the hope that international companies will eventually be interested in local R&D to support manufacturing.

Another factor for ONR to consider is the status, and S&T capabilities, of the military in countries we deal with. Only Australia, Singapore, and India have anything that might be considered even close to a defense lab match to out interests (and NRL's capabilities) in basic or early-applied research[250]. By and large, even in Australia, a large percentage of what we might like to support, either directly or jointly (more on this later, in recommendations for ONR), is done in the university sector (theirs and ours), CRCs, or other government labs (e.g., BMRC). In India, we have traditionally worked most closely with Universities (through the Rupee Fund), but as part of the discussions currently underway between our two countries, we are beginning to explore the possibility of collaboration in, e.g., biopolymers and oceanography with their three naval-oriented defence labs[251], perhaps with ties to the Indian academic community through the Indo-US Forum. Only in Singapore are the defence and civil S&T researchers so well integrated that it's hard to tell them apart.

In New Zealand, our military interaction is basically through TTCP; Australia is also an important participant in this collaboration. In countries like Thailand, Malaysia, Vietnam and the Philippines, the issue is more one of developing or applying technologies that can permit our forces to work together better on matters of common interest, than of joint military-lab based pursuit of advanced S&T (more on this later, also). One important exception to this is tropical diseases, where Navy and Army both have research units in the region (AFRIMS in Thailand, NMRU-2 in Indonesia), that work closely with both civilian and military labs and hospitals.

The military aspect of ONR's work has of course influenced our interactions in Japan, as discussed at some length in Report 3. By and large, we have focused on basic, open-literature published research with university scientists or other government labs, albeit we share interests with JDA's TRDI in ocean science and acoustics, and naval architecture and marine engineering. Given Japan's export regulations regarding the use of technology in military systems, we are even quite restricted in our ability to work with Japanese industry. While the same difficulties do not apply in Korea, we have actually had -- given our military commitments to and presence in the country -- very little visibility into their defense S&T plans and the advanced technology lab's capabilities. Again, most of our S&T interaction has been, and apparently will continue to be, with their universities, other government labs, and industry.

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[250]This is not to say that we do not have significant military-military cooperative programs with many of these nations; indeed we do, and they are very important to both sides. Most of them, however, are targeted at specific military systems or projects, and are conducted under a variety of formal Defence Cooperation in Armaments agreements, as opposed the more basic research and associated sponsorship of international scientists, or collaborative science projects, that characterize most of ONR's international activities.

[251]Following my visit to India, I met on 30 November with Dr. V.K.Aarte, Scientific Advisor to the Secretary of Defence, and Director General, DRDO, India Ministry of Defence, to discuss such opportunities, in anticipation of a Defence Policy Group meeting scheduled for early December.

Country Comments and Recommendations

Japan: Given the Prime Minister's personal attention, a new Cabinet structure with enhanced central control, large financial commitments, and a significantly changed structure of both bureaucracy and performers, S&T in Japan is undergoing some critical transformations. There are still many cultural and structural barriers to overcome (e.g., the hierarchical professorial system combined with lack of rewards for excellence -- picking winners and losers), and the debate on Japan's future military responsibilities in the 'new missions' (from anti-terrorism to peacekeeping and HA/DR) has yet to occur, but as noted above the nation fully understands that getting both science and technology right, and getting them working together synergistically, is critical. In addition to the associated changes within the government/quasi-government lab and university sectors, I expect that with the economic recession there will be less big, showy technology development (like, e.g., the Earth Simulator) in the future, more of an attempt to leverage S&T talent in other nations of the region where it is cheaper and can directly support Japanese industry in those countries, and -- though perhaps this is more hope than prediction -- a softening of the position on the use of commercial technology in at least some military systems.

From our perspective, CSTP's priorities -- life science, ICT, environment, and nano and new materials (plus energy, manufacturing technology, social infrastructure and the Frontier issues) -- are a not unreasonable match to US initiatives; the quality and diversity of Japanese science, and the tools they have built, will continue to be a strong attractant for ONR interest. Japanese top-level attention to gender issues, impelled though it may be in part by long term concerns with labor supply, will reduce if not eliminate some of the barriers to collaboration we have experienced in the past. Further, Japan's openness to foreign scholars, and its investments in the region, offer opportunities for multilateral programs that are in line with CINCPAC's interests. Although my trip was not intended to develop specific ideas for projects, I believe that Japan's interest in improving its posture with regard to earth sensing as a priority for its space program[252], its overall concern with the environment, and its interests in coastal oceanography, could combine to make Japan an important partner with us and others in the region, in a focused oceanographic program in the Asia-Pacific, as a follow-on to ASIAEX (more about this below, starting in the paragraph about the Philippines).

As noted in Report 3, I believe it highly appropriate that we maintain our Asian Headquarters in Tokyo, albeit I see no reason not to fully integrate the tri-service contingent and save considerable money. On the personnel side, a short language immersion course would be very helpful for both the staff and their spouses, and we should encourage ROPOs and permit extended tours[253]. One priority of our Tokyo office should be to follow very closely Japan's evolving S&T policy and investment strategy over the next few years, with the assistance of local support. We should encourage US scientists to make better use of the short term fellowships available through NSF, and visits to AIST labs as they evolve; we should also encourage broader use of the excellent Japanese S&T infrastructure, by both their own and our scientists, through collaborative projects. Similarly, we should encourage and support NSF in broadening the program of NATO-ARI-like workshops, like the one in robotics hosted by Japan last year. And

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[252]I am not up to date on the status of NEMO -- I do know that Singapore had expressed some interest in working with us on that satellite -- but it seems to me not unreasonable to consider a multinational program where NEMO's hyperspectral capabilities could play a major role in regional oceanographic research in the Philippine Basin, South China Sea, Straits, and Indian Ocean.

[253]Personal relationships are always important in science, and perhaps more than normally so in Japan. ROPO - research opportunities for Program Officers -- permits ONR scientists and engineers to devote up to one day a week to their personal research, usually in conjunction with colleagues at a Navy lab or a university. At the IFO offices, this is a very effective way both to stay current, and to gain the trust and confidence of international collaborators; you actually become part of their system in a sense.

in addition to the oceanographic campaign I recommended above, I would encourage discussions with JDA and TRDI about further cooperation in SWAT and *AKUSA.*

Korea: In response to CINCPAC's question, I believe I can say without fear of contradiction that Korea's recently energized S&T strategy fully reflects its maturing and outward looking national perspective. Korea is clearly intent on establishing global intellectual presence, and regional leadership in selected areas; it has put on paper, and seems fully prepared to follow through on, its plans to invest and improve. Korea is extremely heavily committed to IT connectivity and literacy, and its other priorities -- life sciences, mechatronics and systems, new materials, energy and the environment -- are clearly tied to its vision of industrial and commercial strength. While it admittedly has gaps to close and a lot to improve in its management of S&T and the connections between academia and industry, as opposed to Japan its science and technology are well integrated with each other, and balanced. I view as deficiencies the Seoul-centricity of its schooling and thus intellectual population, and the fact that it hasn't tackled the gender issue in S&T. Its overseas investments in the region --e.g. in Vietnam -- may open interesting opportunities for some multilateral projects.

The IFO has not devoted as much effort to Korea as I believe it deserves, particularly given Korea's new S&T strategy and global outlook. I suggest that many, more intensive visits are in order to gain a better appreciation for some of the GRI capabilities, e.g. at KIST and ETRI. To deepen our understanding of Korean strategy and capabilities we should develop a relationship with KISTEP, MOST, and the NSTC Research Councils. We should also broaden our contact with the Universities, and in particular should learn about the activities of the MND University Centers, e.g. those at Seoul National University in underwater acoustics and automated control. And we should definitely ask to visit, and meet the scientists at the ADD Technology Center. I believe we have a much better chance to effectively engage directly with MND on military S&T once we have a better overall appreciation for Korea's capabilities and plans, and preferably after we have initiated some joint research projects with the civil sector institutions. Enhanced collaboration with University researchers should also improve the opportunities for interaction with Korean industry, as their own academic-industrial connections evolve. Finally, as in so many of the countries of the region personal contacts and knowledge are very important; we should seek advice from respected senior naval S&T managers (e.g. Dr Shim of ADD Chinhae) about what arrangements might be appropriate, and also work with the EST section of our Embassy to extend their very useful "Who's Who" pamphlet to include defence scientists.

Philippines: With a couple of possible exceptions, any ONR S&T engagements with the Philippines will likely come about through collaborations of individual Filipino scientists with US colleagues we are supporting, or through meetings at international conferences. The nation's S&T plans are 'in development', and even if they do gel, will likely focus on resource development, agricultural modernization and associated BT, basic IT connectivity, environment, safety and health, and disaster preparedness; I therefore see little opportunity for systematic ONR engagement, particularly since S&T has to be quite far down in the list of things in the Philippines that need fixing. Two factors operating in the country's favor are that President Arroyo is re-electable in 2004, and ASEAN is starting to be serious about regional cooperation; if there is a period of relative stability, integrity, and consistency, improvements will occur.

It will be important to monitor the situation and be alert for opportunities and talent, and ONR should be able to do this through encouragement and quite minor support of the very capable FSN in the Embassy's EST section. NAVOCEANO interacts with OLAG, and ONR should check with them to see if there is any S&T that would abet that relationship. NMRU should be encouraged to extend its Philippine contacts, if it hasn't already done so; there could be

mutual benefit in tropical medicine R&D. And if, as I will suggest in the general recommendations section, ONR becomes more active in PACON, we will thereby maintain contact with the excellent new Maritime Academy of Asia and the Pacific, that over time might develop research capabilities.

Perhaps the most interesting opportunity arose from discussions at the University of the Philippines' Marine Science Institute, as alluded to under my Japan discussion. MSI has considerable interest and experience in oceanic conditions on both sides of the archipelago, and in particular has collaborated with Vietnam on some measurements across the South China Sea. The new Director seems quite well acquainted with other research institutes and programs in the region, and could offer valuable advice on how (or whether we should even try) to structure a multilateral regional oceanographic program, possibly involving NEMO. As I will discuss further below, I believe that as part of our long range strategy we should work out of Singapore (in cooperation with STAS) to strengthen our overall interactions throughout ASEAN, and then work to develop connections among India, Australia, and ASEAN to enhance our knowledge of and presence in the very important maritime region that extends from the Persian Gulf through the Indian Ocean, the Straits, and the South China Sea and Philippine Basin. My sense is that MSI could play an important role in such a plan, if indeed ONR believes it makes sense.

Hong Kong: The one country, two systems arrangement for the Hong Kong Special Administrative region of the PRC is working, and indeed an interesting competitive dynamic between Hong Kong and the mainland is developing as the latter industrializes. Hong Kong has a superb university system, and that is where most of its S&T per se is conducted; and although there is plenty of design and development expertise in business, most of the manufacturing has moved across the border. One interesting facet of the universities is that while almost all the undergraduates are local, about a third of the graduate students are international, many of them from the mainland. Hong Kong's own students seem to prefer to move quickly into business, and in Hong Kong that means principally some aspect of banking, finance, or services, which today also include the associated IT skills. Another important aspect of the system is that it is financially stressed; university resources are today adequate, but with a structurally unsound government income base, the investment spurt that gave rise to HKUST, and provided good infrastructure at the other universities, is unlikely to continue. This situation may, however, induce prioritization of research support, and we should be alert to any such development.

S&T is not a priority issue at our Consulate in Hong Kong, so ONR's access to Hong Kong researchers will have to come through conferences and visits, or possibly through shared PostDocs to help maintain connections to the generation of academics who were educated in the west, as well as to the current community of graduate students. A 'Who's Who' like the one from Korea would be very helpful, as would a more complete inventory of university programs and researchers. There is a Center for Coastal and Atmospheric Research at HKUST that could contribute to any regional oceanography program, and they appear to have a good start toward development a coupled model of the area.

Vietnam: The recent US-Vietnam agreement on S&T cooperation has prompted more ONR attention to that country's research than would otherwise have occurred. For its relatively small size, the country has great ethnic, geographic and biological diversity, providing at once robustness of developmental opportunities, and significant management challenges; these challenges are increased by the need to transition from both a war-based posture and an educational and industrial system shaped by Soviet practices. In S&T, Vietnam has been helped significantly by very intensive analysis of its capabilities, practices, and policy options. It has selected four areas of priority -- IT (in particular software development), BT focused upon its agricultural productivity, automation and manufacturing technology to strengthen its industrial

capacity, and materials. It is investing in "Key Labs" to provide modern infrastructure and build centers of excellence, is restructuring the government labs, and has forced competition both within and between university and government lab sectors to help identify and build on excellence; like others, it is also working to couple these enhanced S&T capabilities to industry.

While given its status Vietnam will for the next several years have to concentrate on capacity building and applied research and training to stimulate industrial growth, it is serious about its investments in S&T and does a very good job of studying the effects of its policy and strategy. Lingering state security concerns likely will adversely affect its opportunities in some sectors such as telecommunications -- this alone could be a major impediment given the importance of IT and 'knowledge' to so many economic sectors -- and the country does have significant needs for infrastructural development and environmental preservation that must be addressed simultaneously with improvements in S&T and industry. However the Vietnamese are entrepreneurial, they have a good agricultural base (coffee, rice) and a stable government, and if they can simultaneously attract investment and build capacity, they have excellent opportunities for rapid economic growth sustained by indigenous capability.

In addition to promoting Vietnamese participation in any regional oceanographic program -- as noted they have collaborated with MSI in the Philippines in the SCS, and they also have significant interest in coastal conditions and processes -- we should watch and support the development of centers of excellence, and where possible take advantage of the US Educational Trust Fund for Vietnamese S&T postgraduate students in the US. Cooperation in manufacturing technology could be beneficial for both sides, while helping build capacity. We should also encourage the Embassy EST section to maintain a flow of information on Vietnamese S&T investments and advances, to help both ourselves and STAS better assess collaborative opportunities.

Thailand: Thailand is one of the very few countries that I visited that seems not to consider S&T a principal tool for economic development. Between its agricultural strength (rice) and foreign investment based upon the availability of high quality inexpensive labor, what R&D investment there is, seems focused on developing a design capability in 2nd and 3rd tier suppliers, and new uses for local products such as natural rubber (each village is being prodded to develop same sort of a product). Except for Bangkok and the industrial centers, there even seems to be relatively little interest in information connectivity. While the US may have considerable commercial interest in the country, there is little to attract us in Thai S&T, with the usual caveats of encouraging the EST section of the Embassy to be alert for changes, and watching for individual academic excellence at conferences and in the literature. We should however revisit NSTDA in a couple of years, after it has relocated to the new industrial park.

There are some multinational organizations in Thailand that are important for multilateral engagement. AFRIMS does exceptional work in EID and vaccines, and seems to collaborate well with NMRU. ADPC is an important node for disaster preparedness. AIT is an excellent source of graduate students from throughout the region. The APEC Foresight Center is a good source of information on S&T strategy and policy plans. Further, the Thai military is extremely professional, and while it does not do S&T per se, it does have needs for technology that are beyond its own capacity to develop, and which would significantly improve their ability to work with US forces in the field. My contacts with them reinforced my belief that ONR should consider 'tech solutions' to such interoperability problems; more below.

Malaysia: I was only briefly in Malaysia, but what I was able to see reinforced the basic impressions I received at CINCPAC. The country's transportation infrastructure is particularly impressive, as are developments in the Multimedia Supercorridor. Should MSC progress anywhere near as planned, it will have to evolve a strong IT S&T and product R&D, as well as

production, capability. There should also be some developmental capacity associated with Malaysian aerospace and automotive industries; they felt that their lack of commercial success in some ventures was due to weak marketing rather than technical quality.

I did not get a chance to meet with the Malaysian military, but it was clear that we have focused more on FMS than on DCA types of interactions to date. Malaysia does have an interest in environmental remote sensing and ocean science and should be a partner in any regional ocean program that evolves. They also have both their own and IMB anti-piracy centers. Basically, I saw just enough to suggest that our rep in Singapore, just a few hours away, should devote more of his time to further investigating the opportunities, and supporting the Kuala Lumpur ODC office in DCA activities; recent agreements with neighboring Singapore that have eliminated at least some of the sticking points between the two countries should help in this regard.

Singapore: ONR's S&T (and US mil-mil) interactions with Singapore have increased several fold in the last couple years. This is in part due to high level policies, and in part to diligent efforts by our local representative and a host of visitors. From the US perspective, Singapore offers strong academic and industrial capabilities in areas of interest to us -- their priorities are electronics, communications, petroleum-based chemicals and -recently- biomedicine -- plus the financial resources to fully carry their share of any collaboration. It's also a very comfortable place to visit and work, and relatively easy to get to, so is more attractive to US academics than most other Asian countries. In addition to the 'general good' of US advanced technological capabilities -- which Singapore can integrate with those it gets from the other nations with which it has close relationships -- their national security strategy, based upon early warning coupled to rapid reaction (with limited expenditure of scarce manpower), is much in line with precisely the sort of high technology military capabilities the US is pushing. Our DOD S&T plans must read like a candy story catalog to them. The only significant constraint on significantly increased S&T cooperation that I can see, is Singapore's weak controls on transshipments, which may limit collaboration in some technologies.

Singapore is a particularly good partner for ONR because of the strong degree of coordination, even overlap, between its Defence developments and its academic-oriented S&T. There is perhaps even better civil-military collaboration in S&T there, than in the US, since their lab structure is less isolated, as well as less concerned with other aspects of acquisition. In addition to having excellent individual investigators, Singapore has developed strong research Institutes and Centres' which make it easy to locate and work with a critical mass of their top talent. Their oceanographic, atmospheric and remote sensing Centres would make excellent partners for regional ocean-related programs, and as noted they have expressed interest about partnering with us in NEMO. The basic point is that there are almost limitless possibilities for mutually beneficial S&T cooperation with Singapore. The task will be for us to prioritize our interests, rather than letting them drive the direction of our interactions.

Singapore is also the logical place, physically, technologically, geographically and politically, from which to reach out to other ASEAN nations. As headquarters for the APEC secretariat, it provides even broader access to Asia-Pacific developments and programs. It is a critical node for any plans to develop and implement a major oceanographic program that links our Indian Ocean and SCS interests. Even if my overall suggestions for enhanced ONR activity in SE Asia are not adopted, there is more to be done in Singapore and the immediate vicinity, than a single person can manage. In addition to the DCA and ONR S&T activities, Singapore is also a most logical location for a senior S&T advisor to the US Embassies in the region.

India: As I write, The US-India Defence Policy Group and its subsidiary Joint Technical Group are meeting in India to discuss future DCA and other mil-mil activities. My own visit was intended as a prelude to these official discussions, and focused closely upon military, especially

naval interests. I however was in India a couple years ago and had a chance then to visit several universities, and ONR/NRL have long had collaborations with Indian academics through the Rupee Fund, to some degree in ocean science and particularly in materials; thus we have a reasonable perspective on overall capabilities. In general, the basic research capabilities in the universities are excellent, albeit the research infrastructure -- much like the rest of the country's infrastructure -- typically is not equivalent to that in top western labs. The reputation of most government labs however, including the defense labs, is not very strong.

If I were to be able to select our approach to S&T collaboration with India, I would suggest we start in the two areas where we have a track record of cooperation with Universities, and where the Navy labs also have capabilities; i.e. materials and oceanography. India will be reluctant to work with us in areas they may consider sensitive (e.g. acoustics and sonar, where they profess self-reliance), and the country has too many other problems to expect a heavy emphasis upon S&T, so we should start simply. The trick even here will be finding a way to work with both civilian and defence communities, which may be complicated by the difference in the mechanisms we use to deal with each (DCA and the Indo-US Forum); as is often the case, our S&T interests bridge the gap. We are helped in India by the strengths of our country team, as well as the top-level commitment by both sides to 'transform' our relationship. If we can develop confidence and working relationships, then in regional METOC in particular India can be an important partner, both bilaterally and throughout the region.

ONR has discussed several other aspects of S&T engagement with India, e.g. Dr Bunch's proposal to teach his naval architecture class while assessing the use of software in the shipbuilding industry. This project would appear to both support Indian Navy interests, and help address one of the enigmas about Indian application of technology in an area where they have demonstrated commercial excellence. Dr Aarte also suggested that they would benefit from training in the use of their new cavitation tunnel, and this might lead to some joint research.

Australia: Australia is of more than normal S&T interest to ONR because of our Navies' evolving strategic cooperation in submarine matters (likely leading to similar efforts in other areas such as AAW). Further, in spite of its relatively small population (less than Malaysia), it 'punches above its weight' in S&T, and has excellent facilities and researchers in academia, DSTO, and other government labs; and for the last decade has been building critical-mass in important areas of technology through its Cooperative Research Centre programme. At present, the Australian 'Innovation System" is focused very heavily upon commercialization, which offers some unique opportunities for leverage; and its civil and military sides are well coordinated, which is another advantage for ONR. None of the weakness of the Australian system impact at all adversely upon the types of cooperative developments we may wish to pursue in the next few years. Indeed Australia is investing quite heavily, albeit very broadly, in many technologies that are of direct interest to us; and their Defence S&T is highly complementary, and through TTCP and experimentation, becoming quite well coordinated with our own.

Although my focus as in the other 10 countries was on investment strategy, I spent a lot of time with Australian researchers, and inevitably found a large number of specific developments that should be of great interest to ONR. Psychology and decision making, UAVs, lasers and photonics, sonar and radar, ICT, and composite materials are examples of just some of the areas where we would benefit from expanded collaboration. I also found that many Australian researchers are quite familiar with ONR, either directly or through their US colleagues; and the majority of their work -- at least that in academia -- is accessible to us. This may decrease somewhat in the future because of the interest in commercialization and thus the increase in applied and proprietary research, but at least we should be able relatively easily to identify the major centers of expertise.

I have two major recommendations for our S&T engagement with Australia; the first, that ONR resubmit our NSDD-38 to State Department and the Embassy to gain approval to station a ships technology expert at DSTO in Melbourne for at least the next couple years, has already been acted upon. As part of this plan, we should use the outstanding capabilities and experience of the new S&T Advisor to the US Embassy, to cover our other, more general interests in the country. This will be relatively inexpensive, and benefit not only ONR and the other services, but also the overall State Department program to improve its contributions to national security through S&T. She fills the gap between EST and ODC that pertains in all the countries I visited, and it will be very interesting to see how much value this important addition to our country team brings.

The second recommendation is that ONR work with OSD to expand the construct of DCA programs to include fully joint developments with Australia, starting with selected topics associated with our cooperation in submarines. Such programs will require up-front agreements to releasability and sharing, and should extend in an integrated way from basic research through advanced technology -- essentially, the full scope of ONR's S&T activities. These programs should be fully joint, in the sense of being defined by a combined IPT (or some such group), mutually funded, and making best use of the civilian and government lab research capabilities of both nations in a completely integrated way, undifferentiated by national border. While we can now have Australians join in 'our' programs, or work together through TTCP or under MOUs and DEAs, etc., we have nothing that explicitly promotes the joint conceptualization of options we both would like to try, followed by programs that intentionally merge the very best of each countries researchers; indeed, we don't even do this at all well with our own other military services. Yet I believe our commitment to cooperation in submarines demands that we develop a process of this sort. The Australians' December sub S&T workshop offers us an opportunity to work with them to look at future requirements, and from those discussions a program such as I envision could emerge.

New Zealand: New Zealand has some excellent academic scientists and a very good, well equipped University system. It also has a spotty yet in places very capable CRI (government owned but operated as commercial enterprises) lab system; NIWA, in particular, could be a good partner in a regional oceanographic program, if the government was willing to help support its participation. New Zealand has recently taken an increased interest in S&T as an essential constituent of economic growth, and is starting to take seriously the need to do a better strategic job of planning and investment. From the military perspective, our S&T relationships are and will remain limited to TTCP, and indeed their capacity is so small that even there, their contributions are minor.

In my relatively short visit I not surprisingly did find some top quality research in the universities in which ONR should be interested, and will pass the information on to our program officers. Overall, as elsewhere, it will be important to understand the magnitude and nature of any serious commitment the country may make to S&T, and be alert to opportunities. The S&T Advisor in Australia should be able to augment the capabilities of our small New Zealand country team in this regard, particularly with the assistance of Royal Society, which keeps a close watch on the local scene.

General Recommendations for ONR International Activities

In my initial report[254], I noted that while my visits were intended primarily to help identify specific activities that would improve the effectiveness of the IFO as it currently operates, there are also a number of strategic issues that need to be addressed. Perhaps the most central of these is the basic rationale for our international activities. This trip has increased my personal conviction that ONR's international role should be construed in the broadest possible sense, and that therefore the organization needs to become much more thoroughly integrated with other elements of US foreign presence and activity, and we need to introduce some new types of collaborative programs. My recommendations reflect this conviction, so I will start by restating my views about the 4 main reasons for ONR to be international.

The main role of ONR's international S&T activity of course is to ensure that we have the best possible scientists and engineers working on questions of concern to the Department of the Navy, irrespective of where they are located. We are a mission agency, so that our fundamental job is to improve the operational capabilities of the 'Navy and Marine Corps After Next'. Simultaneously, we would expect to improve our indigenous S&T capacity through exposure to different approaches and access to international people, places, and ideas. Navy operates globally, and our S&T programs must likewise be global.

Beyond that immediate objective, our international activities should help us avoid technological surprise, and assess US strengths and weaknesses relative to other countries. Part of this is integral to the process of finding the best performers to participate in our programs. But this objective also entails that we understand the S&T policies and strategies of others, since avoiding surprise means knowing not only what has been done, but what others plan to do. This was the whole thrust of my own trip, albeit I was less focused on the 'surprise' issue than simply helping determine what our own future posture should be.

Third, although ONR and its S&T by their nature have most impact on the development of future options, they can also support current operational forces. CNR has introduced a 'Tech Solutions' program specifically to address fleet and force present needs, and the Science Advisors at major commands likewise attempt to bring Navy's technological capabilities to bear on near-term issues. Similarly, it was decided at the IFO Zero Based Review, that our programs should directly support the CINCs' Engagement Strategies. Much of my own effort on this trip has been to that end, in terms of what we can do with the countries in the CINCPAC AOR either bilaterally or as an element in the CINC's efforts to enhance multilateralism, as discussed above under Country Recommendations. I will offer some further suggestions below, in terms of both the nature of our programs and specific topics in which our current S&T programs are weak.

Fourth, ONR's activities should advance our national security agenda by complementing the efforts of others. To do so, we must know what they're doing, and work with them. ONR's current international activities are, to a degree, correlated with those of other Navy units and the other services, both informally, and through official international mechanisms such as TTCP and NATO panels. Recently, with the posting of an ONR-funded engineer to the DCA billet in Singapore, ONR has started to play a much more directly integrated role as a member of a Embassy country team, with direct responsibilities to the Ambassador and CINC as well as to the IFO. We will take a similar step in Australia, by helping support the S&T Advisor to our

[254]Report 1, pp 5-6; see also my ONR Europe CO/TD Report #23 of 18 July 1997, "Going Global", accessible through the ONR IFO web site. www.onrifo.navy.mil

Embassy there.. In general though, although IFO Tokyo and London maintain contact with SAO and EST offices, their activities have been largely independent. Similarly, we are not in close or continuous contact with other international offices in DC, either at OSD or in other government agencies. In consonance with the philosophy of the S&T Advisor to the Secretary of State, that S&T is the bricks and mortar of the three pillars of national security -- diplomacy, the military, and intelligence -- there is much more we can and should do to ensure that ONR's efforts contribute fully to the national agenda abroad.

Before turning to recommendations, I want to say a bit more about the status of ONR's current international programs, to set the stage for some of the changes I will suggest. First, ONR is widely known and well respected overseas. Decades of activity in Europe and Asia by our IFO, plus ONR's open funding policies and high quality program management, have resulted in a large body of accumulated good will. With very minor exceptions international university and government scientists view ONR as a good sponsor, and are more than willing to participate in our programs. This good will is an extremely valuable asset, and helps assure us access to top quality researchers and policy makers. It also significantly increases IFO's value to other US international S&T participants, and in particular to our country teams overseas, where S&T expertise is spotty at best, in both security assistance organizations and EST offices. This value is considerably lessened however by ONR's lack of a clearly enunciated policy regarding its international activities (the 4 objectives described above are simply my opinion, not ONR policy) and thus inconsistent attention to international issues on the part of program officers and managers. Among the deficiencies is that the size of specific international program funding is sufficiently small that many POs ignore it, and thus even if they do sponsor international activity, do so in a way that supports only the narrow but important objective of high quality science; the value added of their activity is missed. Further, as mentioned above, we do not do a good job of coordinating our activities in and from Washington, or with other US agencies abroad, so that again value added is not anywhere near as large as it could be.

Another concern I have is that ONR does very little research that is directly applicable to many of the activities that are high on CINCPAC's list of engagement opportunities. By and large, our overall program is oriented to increasing US traditional 'warfighting' skills, offensive or protective. There is little that is designed specifically to counter asymmetric threats or manage problems like Emerging Infectious Diseases, or to address some of the challenging 'new', 'OOTW' military missions such as humanitarian assistance and disaster management, peace operations, or even counter WMD-drugs-piracy-terrorism. In the wake of 9-11 significant attention is being paid by ONR as well as all other US sponsors to what our programs can to support counter terrorism and homeland defence; but by and large -- witness the FNCs -- ONR's programs are directed ultimately toward what some refer to as 'visually pleasing damage'. This is of course an issue of fundamental strategy for the Navy as a whole, but in the context of this paper the result is that we are doing little in many of the mission areas of immediate operational and international concern to the CINCs. Recognizing the first order importance of conventional military supremacy, especially given our current engagement in Afghanistan, I still wonder if we are paying adequate attention to supporting our forces in the activities that are likely to occupy the vast majority of their military careers, and are important constituents of national security.

That said, I would like to next suggest a number of 'tactical' actions that could improve our activities in most if not all of the countries I visited:

- First, we should continue to encourage all Program Officers to include international researchers in their programs; and we should do a better job of tracking international grant activity, including

talking directly to the POs to try to identify 'second order' activity[255]. Similarly we should follow up on international travel; we really have no coherent idea of who has been where or why.

- Second, NICOP seems to be working quite well (along with VSP and CSP); this is a case where more money would do a lot of good, particularly as ONR's international reach spreads.
- Consortia provide very significant leverage in many ways, and we should take advantage of them, and other 'Centre'-type programs whenever we can. Participating in Australian CRCs is a case in point.
- Symposia are another very useful tool for enhancing multilateral cooperation and gaining access to the work of others. ONR has sponsored the international Naval Hydrodynamics Symposium, and IAMPS, for decades; and recently we introduced a research component to the latter. I would suggest we consider similar tactics in other fields of interest to us, where other routine international fora don't exist. We also should examine ways we can provide S&T support to CINCs multinational meetings and mechanisms (e.g., an S&T section in APAN; ASIAEX briefs to the next Pacific-wide submarine operators conference).
- Topical workshops in the Asia-Pacific region could also have high payoff. I have already suggested, for example, that we support or participate in the NATO-ARI like workshops started last year by NSF Tokyo. Materials and MANTECH figure prominently in the S&T strategy of many of the countries I visited; ONR has strengths in both, and multinational-planning workshops could develop useful specific projects. S&T policy and strategy itself is a topic of wide interest. I have suggested above and will discuss further below a broad oceanographic research campaign in the region, perhaps involving NEMO. Workshops to explore this concept, particularly if held in places like UP's MSI or Vietnam's ocean research lab at Nha Trang, would have both technical and engagement value.
- In addition to individual countries and institutions, there are a number of international groups that merit attention from the IFO. The EC and its labs, OECD, and IIASA are obvious examples in Europe. APEC, whose Secretariat is in Singapore, has numerous groups already studying issues of interest to us. ADPC and AIT in Bangkok and the IMB Anti-Piracy Reporting Center in Kuala Lumpur are other examples. PACON, that I didn't even know existed until I was asked to give its keynote talk, is headquartered in Hawaii and has good connections to the oceanographic community in many Asia Pacific nations.
- Investments in people and infrastructure pay off for many years. As just one example, we have sponsored -- without paying much attention to it -- the PhD research of many international students over the years. These 'alumni' remember us fondly, and since they were by definition working with PI's we considered worthy of grants, are themselves very valuable potential sources of information and future research. Tracking such alumni could be very important in the future, especially as the 'old guard' of US educated senior scientists is passing. In a similar vein, there are a number of US sponsored postgraduate education program targeted at international students (like the Vietnam Education Fund) that we might be able to use to increase international participation in the research of scientists we fund in the States. I also suggested in Report 4[256] that in institutions where US funding is either less important or can not be accepted, PostDocs are

[255]INRIS is fine for direct international funding, but misses anything that is funded through another party, be it a university or a lab; and a lot of our international activity is indeed funded that way, among other reasons because it's easier on the PO. I had printouts for all the countries I visited, but was surprised many times by people who told me that they had ONR grants that I had no knowledge of. This may have been just a minor annoyance on my part, but what it means is that we actually have no idea how much we're spending overseas, or on what, and thus have no way to assess whether we are meeting our strategic objectives -- assuming, that is, that we have some. I am not suggesting new electronic procedures for tracking; the simple solution is just for someone from the international office to talk with each PO and ask them what they're doing (and how the IFO can help...).

[256]Hong Kong, Page 47

an excellent way to establish collaboration; shared PostDocs between US and international scholars can be a particularly effective coupling mechanism. We do some of these things already; I'm simply suggesting that we incorporate such activities more coherently into our international strategy.

- In many instances, I found the most knowledgeable S&T staff at our Embassies to be the FSNs. Local help, whether through them, through ATIP, consultants[257], or direct hires (like Dr Narita) can be exceptionally valuable and relatively inexpensive (e.g., our support to Dr Baltuck in Canberra). I would in particular suggest we use ATIP more than we have, both in technologies where we have no international staff (e.g., optics and photonics; electronics) and to help interpret the directions of investments and policies. We should try to get on the distribution list for information from our Embassies; not just the official cables, but the less formal internal information, newsletters, and brochures they provide to their own staffs, e.g. the Korean "Who's Who". Embassy staff and the FSNs can also be very helpful in locating and interpreting information on S&T in their countries (even something as simple as University catalogs); that's part of their job, they simply don't know that the IFO would find it useful.
- Finally, as I have already suggested, ONR should consider working with the other Services and DOD to integrate the Tri-Service offices, in Tokyo even if not in London. The scientists are completely mingled and work well together; having three separate administrative staffs and procedures to support such a small group makes absolutely no sense; indeed, it's counterproductive and confusing to the people we visit.

In addition to these fairly specific suggestions, I have a few recommendations with regard to ONR's overall approach to international S&T. The basic one, reflected throughout my comments, is that the organization needs to develop and implement its own policy and investment strategy for international outreach. Whether ONR agrees with my philosophy is much less important than that it determine what role it wants to play, and then act accordingly. ONR probably spends something on the order of $20M/year on international activities. This is a significant portion of the total S&T budget of many of the countries I visited. Given the amount of value that could be derived from this expenditure, it deserves to be taken seriously.

I have also tried to emphasize how much more benefit can be gained by ONR, and provided to other elements of our national security community, if ONR's efforts were better coordinated with those of other activities. In particular, I believe ONR should establish closer relationships with STAS (and OES that places the EST officers), the CINC J4s who oversee the security assistance programs in the embassies, and the international staffs of OSD. ONR's placement of Mr. Bergan in the Singapore DCA position (from where he is also providing significant help to the DCA shop in India), and support of Dr Baltuck in Australia, are very good examples of the value-added of cooperative efforts. ONR should seriously consider sponsoring additional staff in similar positions in other countries; any staff we decide to place in Latin America should definitely be done in this manner, rather than as a separate independent office.

In a similar vein, I would suggest that ONR expand its efforts in South Asia, and headquarter them in Singapore. This would let Tokyo focus on North Asia, in particular Japan, Korea, Russia and China, all of which would benefit from more attention. The Singapore Office's principal venue should be ASEAN, and it should also serve as the hub for coordination with Australia -- where our programs will inevitably expand -- and India, where we should watch (and support) the evolution of the DCA office and the Indo-US forum, while starting specific S&T initiatives as recommended above. Basically, my argument is that the ocean area that stretches from the East

[257]E.g., one ODC shop I visited a couple years ago profited greatly from weekly briefings by a retired senior officer whom they hired to simply read the newspapers and stay in touch with his old colleagues

Coast of Africa, through the South East Asian Straits to the latitude of Taiwan, is of great and growing economic and strategic significance. Building an S&T nexus that links India, Australia, and ASEAN, starting with common interests in the ocean, could be a very important contribution to the security of the region. Singapore is the best location from which to do this. This is a very long term goal; but it is the sort of idea that ONR should at least consider as it develops its strategy and discusses the makeup and tasking of its international offices.

There are also several actions ONR should take to improve its support of the CINCs. My suggestions focus on CINCPAC, but should at least in part apply equally well to some other regions. First, the Mid-Pac office can play a stronger role in providing direct support to the CINC's engagement strategy and ONR's international program, through continuing to informally coordinate among the various science advisors on Oahu, by supporting CINC initiatives such as APAN/VIC, and by interacting with other organizations in the area, such as PDC, PACON, and IPRC. My own activities with other agencies have convinced me that both our international programs and the CINC's efforts could be significantly enhanced through astute application of GIS tools, and PDC (and UH) has some expertise in this area that could be brought to bear.

More broadly, and to pick up on one of my earlier criticisms, I strongly recommend that ONR consider what it might be able to do in S&T to improve Navy and Marine Corps capabilities in the "counter" activities, in EID, humanitarian assistance and disaster management, SAR, peace making and peace keeping, and other operations other than war. ONR has already assessed the contributions it can make to counter-terrorism, in response first to the Cole incident, then more intensively as part of the national response to the attacks of 11 September. I suggest that this activity could be logically extended to other concerns, e.g. anti-piracy, counter-drug and counter-WMD. I recognize that DTRA has principal responsibility in these areas, but there are naval aspects of these activities, as well as contributions from basic research, that ONR should consider. The same philosophy applies to the other topics that are core elements of CINCPAC's engagement strategy. One international resource that ONR could enhance to make a very significant contribution in several of these areas is its overseas NMRUs, in CINCPAC's case specifically NMRU-2. As part of developing ONR's international strategy, it would be very worthwhile to examine NMRU's research and surveillance functions, as well as its location, detachments, staffing, facilities, and relationships to other international offices.

Another potentially significant contribution could come from developments to enhance the ability of friendly militaries to work with US forces, or to accomplish missions that contribute directly to our interests. Again, the thrust here is not just 'warfighting', but the full range of engagement activities. As noted in Report 2, this type of need was first brought to my attention at SUBPAC: during joint exercises, we need to communicate administratively with other nations' subs, e.g. over commercial satellite links, and they have no satcom antennas; and we need to help them "stay in the box" while submerged. I encountered many similar needs in discussions with several of the military organizations in south east Asia. They don't have tools that enable them to exercise, plan, or operate effectively with us in OOTW (let alone combat), not do they have the technology to be able to develop them. Our own programs, on the other hand, often are so technologically sophisticated or expensive, that even if we gave the resulting systems away to them they would not be able to maintain or perhaps even operate them. Something like the 'tech solutions' program, oriented toward such engagement issues, could be both inexpensive and productive. It may often involve just relatively simple modifications to commercial systems[258].

[258]One simple example, to repeat myself, might be helping the Thai Army use the Australian Aerosonde UAV for counter-drug border patrol.

This type of program isn't "high tech" by any stretch of the imagination, but it is S&T in the sense of entailing technological responses to the needs of the operational forces.

Finally, I have already mentioned perhaps my strongest recommendation under the discussion of cooperation with Australia. A logical concomitant to our agreement to cooperate in submarine matters, is the joint examination of options for next-generation boats. The agreement specifically calls for the development of capabilities and combat systems that will be common to both nations. To me, that implies the need for truly joint development programs, including aspects of basic research into phenomenology, materials, chemistry, cognition and decision making and the like, as well as the more specific 'system' related developments that traditionally characterize joint R&D programs. While the sort of very close, long term bilateral cooperation in many disciplines and various levels of S&T that I envision being required may not be precluded by the current set of DCA mechanisms, I am not aware of anything of this nature having been tried before, at least not in the recent past[259]. I believe it will therefore be important for ONR to open dialog with our Australian counterparts on their visions of the types of collaborations they envision, then to select a couple of test cases, and thoroughly examine all the releasability, IPR, and other protective barriers that might intrude, as well as what a truly joint program plan may look like. I may be reading more into the agreement than was intended; but if we are in the long run to do much more than just sell each other things, or have Australia piggy back on or participate in our own ongoing system development programs and vice versa, then we need to figure out how to be truly joint in our access to and use of each others best science and technology capabilities, and that is not at all straightforward.

In closing, I can say that I'm pleased to have had the opportunity to be able to so intensively examine S&T in a very lovely area of the world. I greatly appreciate the openness of all my hosts, US and international, and would hope that in attempting to portray what I have learned in a way that is useful to my sponsors I have neither misinterpreted what they told me, nor abused their hospitality. My objective is simply to improve ONR's international posture, and if I have succeeded in that, we will all benefit, and it will have been worth the effort.

[259]Such international collaborations are reasonably normal in basic science, where the objective is fundamental knowledge that is published in the open literature. What I am suggesting here is that this type of activity would be 'vertically integrated' with more applied development and advanced technology in the sense that ONR now conducts some of its own programs, which essentially means fully integrating Australians in our program management system (and Americans in theirs).